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TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

VOLUME XXXVI.

PART I.

SESSION 1950-51.

EDINBURGH:
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1952

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PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CXV

OCTOBER 26, 1950.

Mrs. J. Knox, M.A., D.Sc., President, in the Chair.

The following Office-Bearers were elected for Session 1950–51:—

PRESIDENT.

Professor Sir William Wright Smith, F.R.S.

VICE-PRESIDENTS.

J. B. Simpson, D.Sc.
J. M. Cowan, M.A., D.Sc.
J. Anthony, M.C., M.A., B.Sc.
Miss A. M. MacLeod, B.Sc.

COUNCILLORS.

R. G. Heddle, M.A., B.Sc.
Miss M. Noble, B.Sc., Ph.D.
R. A. Taylor, Ph.D., D.Sc.
Sir Donald Pollock, Bart., O.B.E., LL.D., M.D.
W. A. Clark, B.Sc., Ph.D.
G. Cockerham, B.Sc., Ph.D.
Mrs. J. Knox, M.A., D.Sc.
Professor J. R. Matthews, M.A.
J. T. Johnstone, M.A., B.Sc.
Professor K. W. Braid, M.A., B.Sc.

Honorary Secretary—H. R. Fletcher, D.Sc.
Assistant Secretary—Miss D. Purves.
Cryptogamic Secretary—D. M. Henderson, B.Sc.
Treasurer—J. W. H. Johnson, C.A.
Artist—R. Eudall.
Auditor—C. A. Scott, C.A.

The TREASURER, Mr. J. W. H. JOHNSON, C.A., submitted the following Statement of Accounts for Session 1949–50:—

INCOME.

	£	s.	d.
Annual Subscriptions for 1949–1950	£95	15	0
Arrears of Subscriptions recovered	41	10	0
Transactions sold	16	0	0
Interest on Funds Invested	21	7	8
Subscription to Publications Fund	6	10	5
Income from Botanical Society Trust Fund	12	2	2
Income Tax recovered	16	15	2
Grant from Carnegie Trust	100	0	0
Special Grant from Carnegie Trust towards printing *Transactions*, Vol. 35, part 3	250	0	0
	£560	0	5

EXPENDITURE.

	£	s.	d.
Expenses of Lectures	£2	11	10
Printing *Transactions*, Vol. 35, part 2	235	10	0
Printing *Transactions*, Vol. 35, part 3	287	15	0
Printing and Postage of Notices for Meetings	61	8	7
Teas	1	14	5
Stationery, Postages, etc.	12	9	9
Fire Insurance on Books	0	5	0
Honorarium to Treasurer	5	5	0
	£606	19	7
Excess of Expenditure	46	19	2
	£560	0	5

STATE OF FUNDS.

Life Membership Fund.

Balance of Fund at close of Session 1948–1949		£964 11 7
Add—Life Compositions received		33 15 0
Balance at close of Session		£998 6 7

Ordinary Fund.

Balance of Fund at close of Session 1948–1949	£85 11 3	
Less—Decrease during Session 1949–1950	46 19 2	
Balance at close of Session, subject to printing *Transactions*		38 12 1

Excursion Fund.

Increase during Session 1949–1950		0 11 9
Total Funds		£1037 10 5
Being :—£200 3½% War Stock, at cost	£194 18 3	
£258, 2s. 6d., British Transport 3% Guaranteed Stock, 1978–88 at cost	216 18 6	
£200 3% Defence Bonds at cost.	200 0 0	
£250 3% Savings Bonds 1965–75 at cost	253 18 3	
Sum on Current Account with Clydesdale Bank Ltd.	179 5 5	
	£1045 0 5	
Less—Subscriptions received in advance	7 10 0	
		£1037 10 5

EDINBURGH, 2*nd September* 1950.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1949–1950, and have found them correct. I have also checked the foregoing Abstract, and find it correct. I have seen the securities for the invested funds and have found them in order.

CHARLES A. SCOTT, C.A., *Auditor.*

BOTANICAL SOCIETY TRUST FUND.

SESSION 1949–1950.

INCOME.

Interest on Funds invested	£12 2 2

EXPENDITURE.

To Publications Fund	£12 2 2

EDINBURGH, 27*th September* 1950.—I certify that I have examined the above account and relative vouchers of the Edinburgh Botanical Society Trust Fund, and found the same to be correct.

ALEX. ARNOTT.

His Royal Highness THE DUKE OF EDINBURGH was elected an Honorary British Fellow.

Dr. E. CONWAY, Mr. B. W. RIBBONS, Miss J. CRAWFORD and Miss D. PURVES were elected Ordinary Fellows.

Mr. D. H. N. SPENCE, Mr. J. C. HEDGE, Mr. A. J. C. GRIERSON and Mr. A. MCKELVIE were elected Ordinary Members.

The President for the Session 1950–1951, Sir WILLIAM WRIGHT SMITH, then took the Chair. He referred to the death of three Fellows, Professor R. J. D. GRAHAM, Mr. ANDREW HARLEY and Mrs. K. R. TERRAS.

Dr. C. GIMINGHAM read a paper entitled "The Plant Ecology of St. Cyrus."

NOVEMBER 16, 1950.

Professor Sir WILLIAM WRIGHT SMITH, President, in the Chair.

Mr. W. J. LLOYD, B.Sc., A.M.I.E.E., read a paper entitled "The Electron Microscope." The paper was illustrated by a sound film, *Terra Incognita.*

DECEMBER 7, 1950.

Professor Sir WILLIAM WRIGHT SMITH, President, in the Chair.

Dr. T. P. MCINTOSH, Mr. R. T. GIVIEN and Miss E. DORIS BERTRAM were elected Ordinary Fellows.

Miss M. K. MORRISON was elected a Lady Member.

Miss A. M. MACLEOD read a paper entitled "Changes Accompanying Senescence in Seeds." (See p. 18.)

JANUARY 18, 1951.

Professor Sir WILLIAM WRIGHT SMITH, President, in the Chair.

Miss O. B. ADAMS, Mr. J. C. DODDS, Mr. P. C. HARPER, Mr. N. K. B. ROBSON, Dr. H. BLACKLER, Mr. T. FORRESTER, Mrs. F. L. BALFOUR-BROWNE and Mrs. E. F. PATERSON were elected Ordinary Fellows.

Professor Sir William Wright Smith delivered his Presidential Address.

The following papers were read by title:

1. "Spore Morphology in British Ferns," by Dr. E. M. Knox. (See vol. xxxv, 437.)
2. "Notes on Scottish Fungi," by Dr. R. W. G. Dennis. (See vol. xxxv, 427.)
3. "Recent Additions to the Algal Flora of St. Andrews, Fife," by Dr. H. Blackler. (See vol. xxxv, 435.)
4. "Some Fungi from Sutherland," by Mrs. F. L. Balfour-Browne. (See vol. xxxv, 431.)

FEBRUARY 15, 1951.

Professor Sir William Wright Smith, President, in the Chair.

Miss E. S. McMurtrie was elected an Ordinary Fellow.

Dr. W. Burns read a paper entitled "Factors Influencing the Formation of Adventitious Roots on Stems. A Survey of some Recent Hypotheses."

MARCH 15, 1951.

Professor Sir William Wright Smith, President, in the Chair.

Mr. R. D. Seaton and Mr. J. Bell were elected Ordinary Fellows.

Mr. J. Anthony read a paper entitled "The Structure of Wood."

APRIL 26, 1951.

Professor Sir William Wright Smith, President, in the Chair.

The Report of the Cryptogamic Section was taken as read. (See p. 1.)

Dr. C. E. Foister read a paper entitled "The Weather and Plant Health."

MAY 10, 1951.

Professor Sir William Wright Smith, President, in the Chair.

Canon C. E. Raven read a paper entitled "Early Scottish Botany."

JUNE 14, 1951.

Miss Anna M. MacLeod, Vice-President, in the Chair.

The following papers were read:

1. "Plant Communities of the Serpentine Scree, Unst, Shetland," by Mr. D. H. N. Spence.
2. "A Bacterial Disease of Cocksfoot," by Miss M. Marshall.
3. "A Fungal Disease of Sitka Spruce," by Mr. M. J. Green.

The following paper was read by title:

"Contribution to the Maritime Ecology of St. Cyrus, Kincardineshire," by Dr. C. H. Gimingham.

The Botanical Society of Edinburgh is greatly indebted to the Carnegie Trust for the Universities of Scotland for a substantial grant towards the publication of this number of the *Transactions*.

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TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CXV

Report of the Annual Conference of the Cryptogamic Section, 1950.

By D. M. Henderson.

The Sixty-second Annual Autumn Meeting was held in Callander and district from 29th September to 1st October. Forays were held in the grounds of Cambusmore and Lanrick Castle by kind permission of the proprietors. As Sunday was wet, only a few collections were made along the roadside to Loch Vennachar. Owing to the wet summer, many fungi were past at the time of the foray; collections were good but not outstanding.

A room in the Callander Institute was used for the examination of specimens. The Section is indebted to Dr. R. W. G. Dennis and Mr. R. H. Johnstone for identifying most of the species.

A short business meeting was held. Dr. Foister was warmly thanked for his work for the Section, and Mr. D. M. Henderson was elected Cryptogamic Secretary. In the discussion as to a suitable meeting-place in 1951, Forres and Langholm were mentioned, but the final decision was left to the Secretary.

LIST OF CRYPTOGAMS COLLECTED.

Hymenomycetes.

Amanita citrina (Schaeff.) Roques; muscaria (Linn.) Fr.; phalloides (Vaill.) Fr.; rubescens (Pers.) Fr.
Armillaria mellea (Vahl.) Fr.; mucida (Schrad.) Fr.
Boletus chrysenteron (Bull.) Fr.; erythropus Fr. non Pers.
Calocera viscosa Fr.
Cantharellus cibarius Fr.
Clavaria cinerea Pers.; cristata Pers.; flaccida Fr.; inaequalis Mull.; rugosa Bull.

Collybia butyracea (Bull.) Fr.; confluens Fr.; distorta Fr.; maculata (A. & S.) Fr.
Coprinus atramentarius (Bull.) Fr.; micaceus (Bull.) Fr.
Cortinarius anomalus Fr.; cinnabarinus Fr.; elatior Fr.; paleaceus Fr.; rigidus (Scop.) Fr.; scandens Fr.
Crepidotus mollis (Schaeff.) Fr.; variabilis (Pers.) Fr.
Dacryomyces deliquescens (Bull.) Duby.
Daedalea quercina Pers.
Exidia glandulosa Fr.; thuretiana (Lév.) Fr.
Fomes annosus (Fr.) Cooke.
Flammula sapinea Fr.
Galera hypnorum (Batsch) Fr.; tenera (Schaeff.) Fr.
Ganoderma applanatum (Pers.) Pat.
Hydnum repandum (Linn.) Fr.
Hygrophorus calypteraeformis Berk.; ceraceus (Wulf) Fr.; chlorophanus Fr.; coccineus (Schaeff.) Fr.; fornicatus Fr.; hypothejus Fr.; laetus (Pers.) Fr.; nigrescens Quél.; niveus (Scop.) Fr.; pratensis (Pers.) Fr.; psittacinus (Schaeff.) Fr.; puniceus Fr.; pustulatus (Pers.) Fr.; unguinosus Fr.
Hypholoma fasciculare (Huds.) Fr.
Inocybe geophylla (Sow.) Fr.; var. lilacina Fr.
Laccaria laccata (Scop.) Cke.; amethystina (Vaill.) Cke.
Lactarius blennius Fr.; camphoratus (Bull.) Fr.; glycyosmus Fr.; mitissimus Fr.; pallidus (Pers.) Fr.; pyrogalus (Bull.) Fr.; quietus Fr.; subdulcis (Pers.) Fr.; torminosus Fr.; vellereus Fr.; vietus Fr.
Lepiota amianthina (Scop.) Fr.
Marasmius esculentus (Wulf ex Fr.) Karst.; peronatus (Bolt.) Fr.
Mycena acicula (Schaeff.) Fr.; adonis (Bull.) Fr.; alcalina Fr.; ammoniaca Fr.; epipterygia (Scop.) Fr.; galericulata (Scop.) Fr.; galopus (Pers.) Fr.; lineata (Bull.) Fr.; luteo-alba (Bolt.) Fr.; metata Fr.; polygramma (Bull.) Fr.; pura (Pers.) Fr.; sanguinolenta (A. & S.) Fr.
Naucoria escharoides Fr.
Nolanea staurospora Bres.
Omphalia fibula (Bull.) Fr.; var. swartzii Fr.; umbellifera (Linn.) Fr.
Panaeolus campanulatus var. sphinctrinus (Fr.) Bres.
Paxillus involutus (Batsch) Fr.
Pholiota squarrosa (Mull.) Fr.
Pleurotus cornucopiae (Paulet) Pers.; porrigens (Pers.) Fr.
Polyporus amorphus Fr.; betulinus Fr.; stipticus (Pers.) Fr.
Polystictus versicolor (Linn.) Fr.
Psathyra gossypia (Bull.) Fr.
Psathyrella spadicea-grisea (Schaeff.) A. H. Smith.
Psilocybe bullacea (Bull.) Fr.; sarcocephala Fr.; semi-lanceata Fr.
Russula atro-purpurea Kromb.; azurea Bres.; cyanoxantha (Schaeff.) Fr.; delica Fr.; emetica (Schaeff.) Fr.; fellea Fr.; fragilis Fr.; heterophylla Fr.; nigricans Fr.; ochroleuca Fr.; rosea Quél.
Stropharia semi-globata (Batsch) Fr.
Tricholoma lascivum (Fr.) Gillet; saponaceum Fr.; terreum Fr.
Tubaria furfuracea (Pers.) Gillet.

REPORT OF THE ANNUAL CONFERENCE OF THE CRYPTOGAMIC SECTION, 1951.

By D. M. HENDERSON.

The Sixty-third Annual Conference was held in Langholm, Dumfriesshire, and district, from 28th to 30th September. Forays were held on neighbouring properties by kind permission of the Duke of Buccleuch.

The grounds of Langholm Lodge were visited on the 28th and 29th, but the larger fungi were not plentiful. The afternoon of the 29th was devoted to the examination of the collections in the science room of Langholm Academy, where the rector, Mr. Pattie, had provided every facility. At a short business meeting in the evening it was agreed to hold the next autumn meeting in the Blairgowrie district, at an early date in September. It was suggested that a Spring foray might be arranged jointly with a Botanical Society excursion.

The banks of the River Esk below Langholm yielded some interesting fungi on the 30th, but from the number of decayed fructifications it was evident that their peak was over. *Boleti* were notably scarce.

Throughout the three days the weather was very fine and conditions were ideal for collecting. A total of ten attended.

LIST OF FUNGI COLLECTED.

BASIDIOMYCETES.

HYMENOMYCETES.

AMANITA CITRINA (Schaeff.) Roques; MUSCARIA (L.) Fr.; RUBESCENS (Pers.) Fr.
AMANITOPSIS FULVA (Grev.) Rea.
ARMILLARIA MELLEA (Vahl.) Fr.; MUSCIDA (Schrad.) Fr.
CANTHARELLUS CIBARIUS Fr.; TUBAEFORMIS (Bull.) Fr.
CLITOCYBE AURANTIACA (Wulf.) Studer; INFUNDIBULIFORMIS (Schaeff.) Fr.; NEBULARIS (Batsch) Fr.
COPRINUS ATRAMENTARIUS (Bull.) Fr.; PLICATILIS (Curt.) Fr.
CORTINARIUS CINNAMOMEUS Fr.; ELATIOR Fr.; PALEACEUS Fr.; TORVUS Fr.
CREPIDOTUS CALOLEPIS Fr.
FLAMMULA CARBONARIA Fr.
HEBELOMA CRUSTULINEFORME (Bull.) Fr.; MESOPHAEUM (Pers.) Fr.

Hydnum repandum (L.) Fr.

Hygrophorus calypteraeformis Berk.; ceraceus (Wulf.) Fr.; chlorophanus Fr.; coccineus (Schaeff.) Fr.; laetus (Pers.) Fr.; pratensis (Pers.) Fr.; psittacinus (Schaeff.) Fr.; unguinosus Fr.

Hypholoma fasciculare (Huds.) Fr.; hydrophilum (Bull.) Fr.; sublateritium Fr.; velutinum (Pers.) Fr.

Inocybe geophylla (Sow.) Fr.; geophylla var. lilacina Fr.

Laccaria laccata (Scop.) Cke.; amethystina (Vaill.) Cke.

Lactarius blennius Fr.; camphoratus (Bull.) Fr.; pallidus (Pers.) Fr.; plumbeus Fr.; pyrogalus (Bull.) Fr.; quietus Fr.; subdulcis (Pers.) Fr.; vellereus Fr.

Marasmius confluens (Pers.) Karst.; dryophilus (Bull.) Karst.; peronatus (Bolt.) Fr.; epipterygia (Scop.) Fr.

Mycena galericulata (Scop.) Fr.; galopus (Pers.) Fr.; haematopus (Pers.) Fr.; inclinata Fr.; rubro-marginata Fr.; vitilis Fr.

Nolanea staurospora Bres.

Omphalia maura Fr.

Panus torulosus (Pers.) Fr.

Panaeolus campanulatus (L.) Fr.

Paxillus involutus (Batsch.) Fr.

Pholiota squarrosa (Mull.) Fr.

Psathyrella gracilis Fr.

Psilocybe semi-lanceata Fr.

Russula atro-purpurea Kromb.; cyanoxantha (Schaeff.) Fr.; delica Fr.; drimeia Cke.; emetica (Schaeff.) Fr.; farinipes Romell; fellea Fr.; fragilis Fr.; nauseosa (Pers.) Fr.; nigricans Fr.; ochroleuca Fr.

Stropharia aeruginosa (Curtis) Fr.; semi-globata (Batsch.)Fr.

Tricholoma rutilans (Schaeff.) Fr.; scalpturatum Fr.

Tubaria furfuracea (Pers.) Gillet.

Boletus badius Fr.; chrysenteron (Bull.) Fr.

Calocera viscosa (Pers.) Fr.

Clavaria cinerea (Bull.) Fr.; fumosa (Pers.) Fr.; rugosa (Bull.) Fr.

Exidia nucleata (Schwein.) Rea.

Fomes annosus Fr.

Ganoderma applanatum (Pers.) Pat.

Polyporus adiposus B. & Br.; giganteus (Pers,) Fr.; stipticus (Pers.) Fr.

Stereum purpureum (Pers.) Fr.

Trametes gibbosa (Pers.) Fr.

Tremellodon gelatinosum (Scop.) Pers.

Tremella foliacea (Pers.) Fr.

Gasteromycetes.

Scleroderma aurantium Pers.

Phallus impudicus (L.) Pers.

Uredinales.

Coleosporium petasites Lev. on *Petasites hybridus* (L.) Gaertn., Mey & Scherb.

Phragmidium violaceum Wint. on '*Rubus fruticosus.*'

Puccinia bistortae (Str.) DC. on *Polygonum bistorta* L.; circaeae Pers. on *Circaea lutetiana* L.; lychnidearum Link on *Melandrium dioicum* (L.) Coss & Germ.; menthae Pers. on *Mentha aquatica* L.; violae DC. on *Viola* sp.

Pucciniastrum circaeae Speg. on *Circaea lutetiana* L.; abieti-chamaenerii Kleb. on *Chamaenerion angustifolium* (L.) Scop.
Melampsora larici-caprearum Kleb. on *Salix caprea* L.; larici-populina Kleb. on *Populus trichocarpa* Torr. & Gray.
Melampsoridium alni Diet. on *Alnus glutinosa* (L.) Gaertn.
Trachyspora alchemillae (Pers.) Fuckel on '*Alchemilla vulgaris*.'
Triphragmium ulmariae Wint. on *Filipendula ulmaria* (L.) Maxim.
Uromyces geranii on *Geranium sylvaticum* L.

Ustilaginales.

Urocystis anemones (Pers.) Wint. on *Ranunculus repens* L.

ASCOMYCETES.

Bulgaria inquinans Fr.
Helvella elastica Bull.
Leotia lubrica Pers.
Macropodia macropus Pers.
Phyllactinia corylea on *Betula pendula* Roth.
Rhizina undulata Fr.

THE OCCURRENCE OF INTRAHYPHAL MYCELIUM IN GONATORRHODIELLA HIGHLEI.

By W. BLYTH.
(Department of Botany, University of Edinburgh.)

(With Plates I and II.)

(Read 19th May 1949.)

In previous papers [3 & 4] the writer described observations made on the morphology and parasitism of *Gonatorrhodiella highlei* A. L. Smith. During the investigations the occurrence of intrahyphal mycelium was noted in this fungus, and in the following paper examples are described and the phenomenon of "self-penetration" is discussed in a general way.

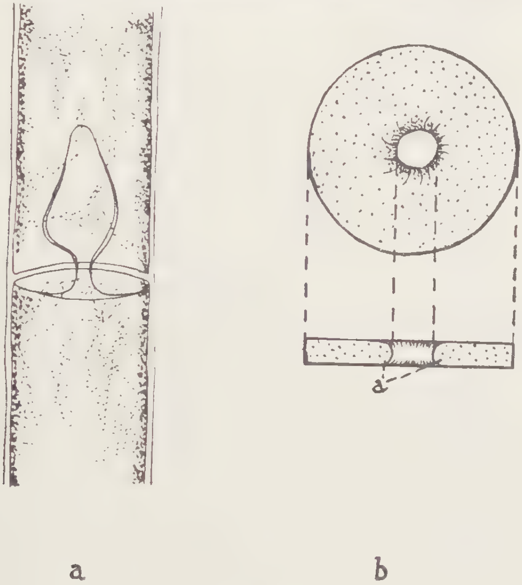
THE FORMATION OF INTRAHYPHAL MYCELIUM.

Evidence of the formation of intrahyphal mycelium in *Gonatorrhodiella highlei* was gained in cultures where the media used were fungal extract agars, and in nature from the colony of the fungus which occurred on poplar bark.

Endogenously developed hyphae were observed in both old and young cultures. In cultures six to ten weeks old they were confined to the upper three cells of young actively growing conidiophores which were still producing conidia from their terminal bulbs. In the vegetative mycelium of the fungus, intrahyphal growths were observed in cultures which had been incubated for three months at 18–20° C., and also occurred during regeneration of the fungus within hyphal fragments sown on extract agars. Under natural conditions, limited intrahyphal growth took place during the proliferation of the conidiophores.

All intrahyphal growth-forms have their origin in the upper transverse septum of a cell which may become entirely evaginated, or only partly evaginated, during the course of development to produce a sac which enters the cell above. They obey the polarity of growth shown by the hypha in which they are produced.

Text-fig. 1, *a* shows an example of localised septal evagination at an early stage of development, in which the growth has originated from the central area of the transverse septum, the area which most commonly gives rise to intrahyphal mycelia. The occurrence of a distinct septal pore in most septa of the conidiophores is common in this fungus. Intrahyphal growths which have their origin in the area of the septal pore appear to develop by the assumption of meristematic activity by the zone of the cell-wall which defines the limits of the pore. A diagrammatic representation of a transverse septum showing this zone is given in text-fig. 1, *b*. In that intrahyphal growths are closed at the upper end from their first appearance, closure of the pore must be presumed to occur before or during the earliest stages of septal evagination. It has not been possible to observe pore closure, but in the very early stages of the process of evagination, the continuity of the septum has been clearly defined in many cases.



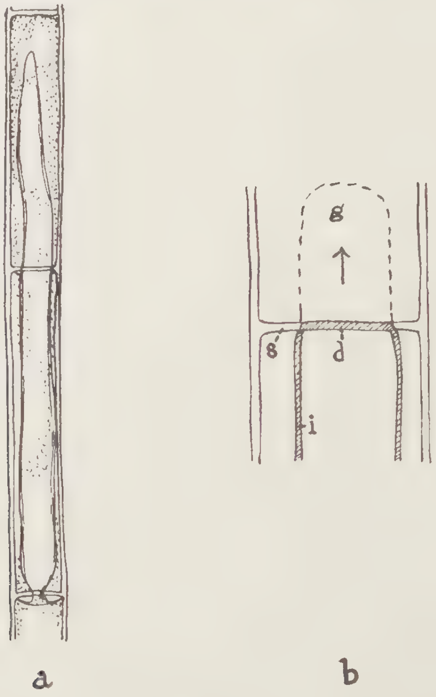
TEXT-FIG. 1.

(*a*) An early stage in the development of an intrahyphal growth in the cell of a conidiophore of *G. highlei*, showing localised evagination of the transverse septum. × 1600.

(*b*) A diagrammatic representation of a transverse septum, showing a central pore, and the area (*a*) from which intrahyphal growth proceeds.

In the most simple examples the continued growth of the apex of the first-formed sac causes the appearance of a thin-walled, septate hypha, which grows longitudinally within the enclosing cell, gradually increasing in width to fill the cell. Increase in width occurs a short distance from the base in the first instance (fig. 1) and moves progressively upwards.

Intrahyphal growths have been observed to pass through conidiophore septa and invade cells higher in the conidiophore (text-fig. 2, *a*). During the passage of an intrahyphal growth through the upper transverse septum of an enclosing cell the septum suffers no immediate disintegration. It appears that the tip of the growth effects a fusion with the septum and that the circular fusion zone continues active growth, whilst the remaining area of the septum, which is connected to the longitudinal cell-wall of the hypha, forms a collar round the intrahyphal growth (text-fig. 2, *b*).

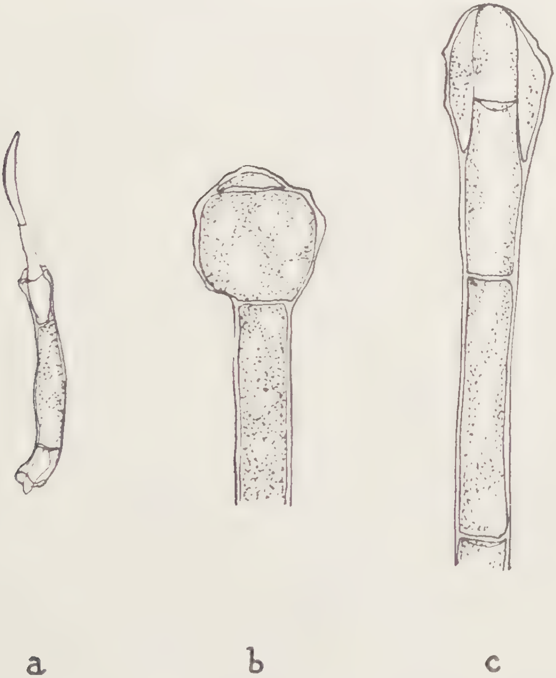


Text-fig. 2.

(*a*) Part of a conidiophore of *G. highlei*. Septal evagination has given rise to an intrahyphal growth passing through a transverse septum higher in the conidiophore. ×560.

(*b*) A diagrammatic representation of the passage of an intrahyphal growth through a transverse septum. The zone of fusion (d) between the intrahyphal growth (i) and the transverse septum (s) continues growth (g) into the next cell of the conidiophore.

Fusion has been seen to occur between endogenously developed hyphae produced within the same enclosing cell. Several prostrate branches were observed to grow from the hyphae of a *Gonatorrhodiella* colony which lay at the surface of *Nectria* extract agar. They arose laterally from hyphal cells, and simulated the appearance of young conidiophores during the earlier stages of their growth.



TEXT-FIG. 3.

(*a*) The regeneration of a fragment of the mycelium of *G. highlei* by means of intrahyphal growth. ×600.

(*b*) The formation of a transverse septum at the apex of the terminal bulb of a conidiophore of *G. highlei*. ×600.

(*c*) Total evagination of the upper transverse septum of the subterminal cell of a conidiophore of *G. highlei*. ×600.

In one of these structures an intrahyphal growth occurred in the apical cell (figs. 2 and 3). The intrahyphal growth was joined to the subterminal cell of the parent hypha at two separate points, but formed a continuous loop at the upper end of the enclosing cell. This suggests the growth, in the first instance, of two separate hyphae from the upper septum of the subterminal cell, and the final union of the two by fusion at a higher level in the enclosing cell.

The intrahyphal growths, which are formed within cells in contact with agar, finally become free from the cells by the formation of lateral branches. This is also shown in fig. 3, where each outgrowth is given off from a short, slightly distended cell, and emerges from the enclosing cell-wall to become free to the surrounding agar medium.

During the regeneration of the mycelium of the fungus from hyphal fragments sown on fungal extract agars, intrahyphal growth-forms, which have originated in localised septal evaginations, are comparatively common. An example is shown in text-fig. 3, *a*. The investigation has made it clear that localised septal evaginations, whether centrally or more peripherally placed, are the most usual means by which the formation of intrahyphal mycelium is attained.

In conidiophores obtained from extract agar cultures, and from the natural habitat of the fungus on poplar bark, however, intrahyphal growth-forms originating in the total evagination of a transverse septum have been found to bring about a type of conidiophore proliferation. In the earliest stages of development, a transverse septum forms at a variable distance from the apex of the terminal bulb of a conidiophore which is still in a sporing condition (text-fig. 3, *b*, *c*). By the upward growth of this septum, the original upper wall of the bulb immediately above it is ruptured, and forms a collar to the new outgrowth (figs. 4, 5 and 6).

It cannot be clearly ascertained whether intrahyphal growth by means of total septal evagination is the only method involved in some proliferations, which at a final stage of their development show only short collars at the point of union with the former apical bulb, such as are shown in figs. 4 and 5. Examination of conidiophores showing early stages in proliferation has suggested that some proliferations may have their origin in a tangential splitting of the wall at the apex of the bulb, so that the collar represents the outer of the two walls which are so formed, after the outgrowth of the inner wall has taken place.

The proportion of conidiophores in which intrahyphal growth or tangential wall-splitting has been instrumental in effecting proliferation is small. The majority of conidiophores show no evidence of these processes, and proliferation is apparently brought about by direct growth from a localised area of the wall of the terminal bulb. Some conidiophores in which several proliferations have occurred have been observed to show both segments bearing collars and those devoid of them.

Cells within which intrahyphal growth-forms develop may or may not possess cell contents. In fig. 1 the enclosing cell contains a considerable quantity of protoplasm which appears to be in a state of dissolution, whereas the evaginating cell is almost empty and has passed some of its content to the intrahyphal growth. The enclosing cell in fig. 3 is almost devoid of protoplasm, and very little cell-content remains in the cell from which the intrahyphal growth originated. The occurrence of intrahyphal growth has never been recorded prior to the elaboration of conidia, but is usually observable in conidiophores which have already shed conidia, or are still in the process of sporing. This point, taken together with the fact that the lower cells of conidiophores have frequently been observed to lose their protoplasmic content during sporing and shedding of the conidia, seems to imply that drain on the protoplasm occasioned by asexual reproduction may provide the stimulus for the development of intrahyphal mycelium.

In the vegetative mycelium of the fungus growing in old cultures, and during regeneration of the mycelium from hyphal fragments, however, intrahyphal growths invariably appear in cells which are empty. Whether the protoplasm was absent before septal evagination, or whether it was lost in participation in the development of the intrahyphal growth, is not clear.

Discussion.

From the various observations which have been made of self-penetration, or formation of intrahyphal mycelia, in *Gonatorrhodiella highlei* it has been established that two distinct methods of development are involved. The two differ in the extent to which the transverse septum of the cell which gives rise to the intrahyphal growth participates during the early stages of evagination.

In the prostrate basal hyphae of the fungal colony, and in the lower cells of the conidiophores, only a limited, central or peripheral zone of a transverse septum is evaginated to initiate an intrahyphal growth, and the position of the septum can be easily distinguished after development is complete. In the subterminal cells of freely sporing conidiophores, however, the entire upper transverse septum may be evaginated to form a hypha by which the eventual proliferation of the conidiophore is attained. Where this occurs, the transverse septum is wholly incorporated in the new growth and thus loses its identity.

The distinction between localised and total evagination was mentioned by Lindner[15] in a valuable review of a number of plants which demonstrate the phenomenon of self-penetration. Although the number of fungi which show the phenomenon is small, various examples of intrahyphal growth from localised evagination have appeared in the literature from time to time. From these references the following fungi may be mentioned: *Sclerotium hydrophilum*[17], *Alternaria*[15], *Botrytis cinerea*[1], *Rhizoctonia solani*[11], *Pullularia pullulans*[13], *Ascobolus magnificus*[10], *Gymnosporangium* spp.[9], *Ascoidea rubescens*[18], *Chaetomium Kunzeanum*[19], and *Saprolegnia ferax* var. *hypogyna*[16].

In their method of development and appearance, intrahyphal growths which have originated from localised septal evaginations in the above fungi are similar to those which have been described for *Gonatorrhodiella* during the present investigation. In certain cases, notably *Pullularia pullulans*[13], *Botrytis cinerea*[1] and *Ascoidea rubescens*[18], intrahyphal growths have been observed to abstrict conidia within the cells containing them. The formation of endoconidia has not, however, been seen in *Gonatorrhodiella*. The regeneration of hyphal fragments by self-penetration, which has been described in the latter fungus, was mentioned by Duggar and Stewart[11] in their researches on *Rhizoctonia solani*.

As a result of his work on *Botrytis cinerea*, *Epicoccum purpurascens* and *Alternaria* sp., Lindner[15] commented on the frequency of the occurrence of intrahyphal mycelia in old cultures, and their rarity in young fungal colonies. Dodge[10] added a similar observation for *Ascobolus magnificus* and Walker[18] for *Ascoidea rubescens*. The degeneration or death of hyphal cells in fungal colonies which have been growing on media for some time is common, and may be attributed in part to the depletion of nutrients and moisture from the substrate. In those fungi which display the phenomenon of self-penetration, intrahyphal developments have often been directly associated with dead or degenerate cells. Both Lindner[15] and Dodge[10] have viewed many of these growth-forms as "bridging hyphae", which, by their passage through senescent or dead areas of the hypha, connect successive healthy segments. "Bridging" involves the formation of a cell outgrowth which effects fusion with a further cell at some distance from its place of origin, intervening cells thus losing their significance as functional units. Many instances of the phenomenon have been figured for *Ascobolus magnificus*[10] and *Alternaria* sp. [15]. Lewis[14] has also recorded "bridging" in the Red Alga, *Griffithsia Bornetiana* in which he describes and illustrates the continuity of the algal filament which is brought about by the formation of intrafilamental outgrowths, which enter a dead cell from the cells on either side and finally fuse with each other. Fusions between intrahyphal mycelia which have separate points of origin are also known to occur in the fungi. Lindner[15] has recorded several fusions in *Alternaria* sp. which have occurred both within enclosing cells, and outside the "parent" hypha. An example of fusion within a single enclosing cell has been described in *Gonatorrhodiella*, but no instances of fusion between branches of intrahyphal mycelia which have subsequently become free by outgrowth from the enclosing hypha have been forthcoming.

The degeneration of cells prior to their penetration by intrahyphal growths is further illustrated by Dodge[9] in his work on *Gymnosporangium clavariiforme*, *G. nidus-avis*, *G. macropus*, and *G. globosum*. In these fungi the teleutospores originate from the subterminal cells of the tissue which composes the teleutospore sorus. Before the evagination of the upper transverse septum of a subterminal cell, the terminal cell undergoes nuclear and cytoplasmic degeneration, so that in many cases the outgrowth enters an empty cell within which it differentiates to give a teleutospore.

This frequent occurrence of the penetration of degenerate or dead cells by intrahyphal growths prompted Lindner[19] to forward the suggestion that the formation of septal evaginations may be facilitated by the reduction in osmotic pressure attendant upon degeneration. Klöcker and Schiönning[13], in their account of self-penetration in *Pullularia pullulans*, preferred to consider the phenomenon as one incorporating a form of parasitism, where "strong" cells could be regarded as parasitising adjacent "weak" cells.

During the present work on *Gonatorrhodiella highlei*, the variation in the content of enclosing cells has been mentioned, and doubt expressed as to the quantity of protoplasm present within them prior to the development of intrahyphal growth-forms. It may be the case that where a certain amount of protoplasm exists, it acts as a source of nutrients for the developing growth. No evidence has been forthcoming of the contraction of the protoplasm of an enclosing cell, and the subsequent development of a wall around it, as was shown in *Botrytis cinerea* by Beauverie and Guilliermond[1].

Whether or not osmotic pressure relationships are involved in the process of intrahyphal development, it appears that the occurrence of the latter is always correlated with a physiological drain, which is occasioned either by sporing in the case of conidiophores, or by depletion of nutrients and moisture from the substrate in the case of the vegetative mycelium of the fungus in old cultures. The rather limited type of growth which the fungus shows on fungal extract agars is indicative of the fact that these substrates do not provide the full nutrient requirement of the fungus, a condition which may add to the physiological drain set up in the conidiophores by sporing.

Irrespective of the method by which intrahyphal growth-forms are developed, they all tend to bring about an increase in the total surface area of the fungus. This might be viewed as a plant response to adverse conditions by which a greater absorptive surface is developed in the substrate in those instances where intrahyphal growths become free from their enclosing cells. In young, actively sporing conidiophores, partially empty cells frequently develop intrahyphal growths which enter cells in which a greater protoplasmic content is present. This may also be regarded as a cell response, bringing about an increase in absorptive surface at a remaining source of food materials.

The power to develop self-penetration is only known to be possessed by a limited number of plants. It seems that the majority of fungi do not show the phenomenon even when growing under extremely disadvantageous conditions in culture. It is likely, therefore, that the expression of self-penetration is dependent on a genetic basis.

Fungi which display self-penetration in which total septal evagination is involved are rare. Lindner[15] discovered an example during his work on *Epicoccum purpurascens*. In this fungus short lateral hyphal branches are cut off by septa from the cells in which they have their origin. Backwardly directed evaginations of these septa have been shown to give intrahyphal growths within the parent hypha. A curious form of total evagination is also to be found in *Inzengaea*. Borzi[5] records the formation of bladder-like cells in the hyphae which arise from the outer layers of the perithecial wall, and to which he ascribes a protective function. By the total evagination of the upper transverse septum of the subterminal cell of such a hypha, a short intracellular growth appears in the bladder cell.

Although instances of the kind mentioned above have rarely been recorded, total septal evagination is known to operate under somewhat different circumstances, and is characteristic of the genus *Saprolegnia*[8]. It results in the process of sporangial proliferation. The sporangium sheds its contents, and by the total evagination of the upper transverse septum of the subsporangial cell the cavity of the sporangium receives an outgrowth from which a further sporangium is later derived. The process may be repeated many times in the same sporangiophore. It is of interest that localised septal evagination from the subsporangial cell may replace the total form. Coker[8] figures both types of development in *Saprolegnia monoica* var. *glomerata*. Normal sporangial proliferation occurs together with abnormal proliferations in which localised septal evaginations bear terminal oogonia and antheridia. The phenomenon of sporangial proliferation, attained by a method similar to that described in *Saprolegnia*, has also been recorded by Butler[7] in *Pythium proliferum* and by Blackwell in *Phytophthora*[2].

A somewhat more complex form of proliferation is shown by the "hemiascus" of *Ascoidea rubescens*. The precise nature of the "hemiascus" of this fungus is not entirely clear, but it has been stated by Walker[18] to be an apogamously developed ascus. In general, proliferation which is identical in mechanism to that in *Saprolegnia* follows upon the evacuation of the ascus. The new outgrowth, which arises by the total evagination of the upper transverse septum of the subascal cell, enters an almost empty ascus. A certain amount of variation does, however, occur in the process.

Brefeld[6] recorded instances in which the evagination of the septum proceeded whilst the major proportion of the ascus contents still remained. He therefore considered that proliferation assisted the function of ascospore dispersal by the pressure to which it gave rise. From her researches, Walker[18] concluded that such examples were abnormal, and claimed that osmotic pressure relationships were more clearly involved in bringing about spore dispersal.

In some of the proliferations of the conidiophores in *Gonatorrhodiella highlei* the new hyphal growth may also arise from the upper transverse septum of the subterminal cell, and penetrate a terminal cell which still contains protoplasmic contents. *Saprolegnia* spp., *Ascoidea rubescens* and *Gonatorrhodiella highlei* may therefore be considered to present a series in which the adoption of true intrahyphal growth by a form of total septal evagination is developed. In the sporangia of *Saprolegnia* spp., and in the normal asci of *Ascoidea rubescens*, the growth which arises from the septum of the evaginating cell enters a cell cavity usually devoid of contents and open at the upper end. In the strictest sense, true intrahyphal development is not present, although the method of growth adopted is mechanically the same. In the abnormal cases of ascus discharge in *Ascoidea*, the hyphal growth enters the ascus whilst ascospores and epiplasm are present, but the apex of the ascus is still open. In

Gonatorrhodiella intrahyphal growth of a true type is shown by the entry of a septal evagination into a closed and active cell. As far as the writer is aware, the type of proliferation which results from the development of intrahyphal growth in *Gonatorrhodiella* is rare.

In a recent paper Hughes[12] investigated the genus *Sporochisma*. He describes and provides illustrations of the capitate hyphae which accompany the conidiophores of species of the genus. These hyphae are similar in type to the conidiophores of *Gonatorrhodiella* in that they possess terminal bulbs through which continued growth of the hypha is attained. From an examination of the figures, it is clear that some of these proliferations most probably resulted from the mechanism of total septal evagination of subterminal cells, as "collars" occur at the areas of proliferation.

Summary.

The occurrence of intrahyphal mycelium was noted in the conidiophores and mycelium of *Gonatorrhodiella highlei*. Two methods of development are distinguished. In the first, intrahyphal growth-forms arise by the localised evagination of a cell septum, and in the second by total evagination. Localised evagination is the more usual, and has been recorded in both conidiophores and mycelium, whilst total evagination brings about a specialised form of proliferation in the conidiophores.

The conditions under which "self-penetration" occurs and the mechanism involved in the process are discussed, and the view that physiological drain is a dominant factor concerned is put forward.

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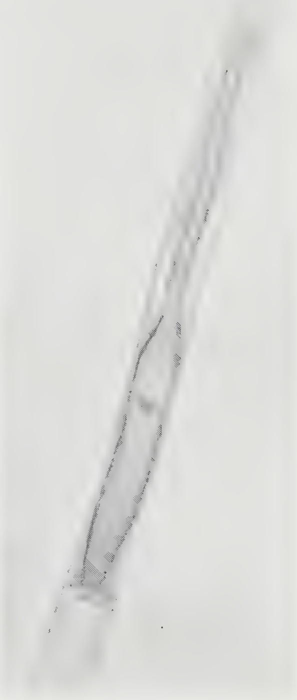

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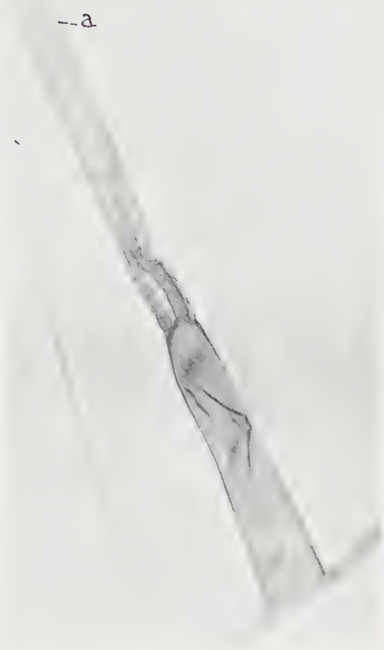

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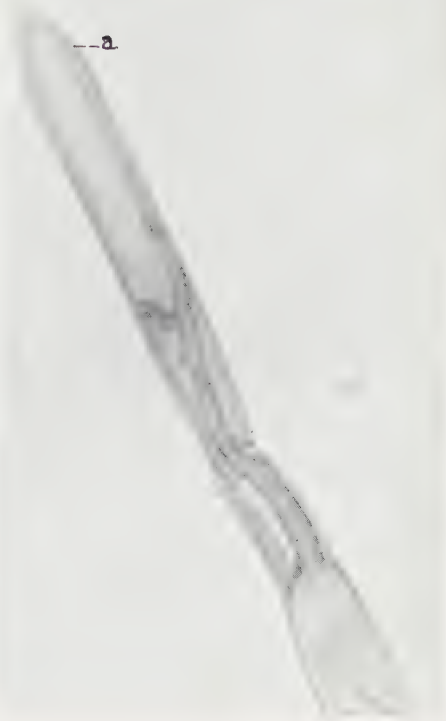

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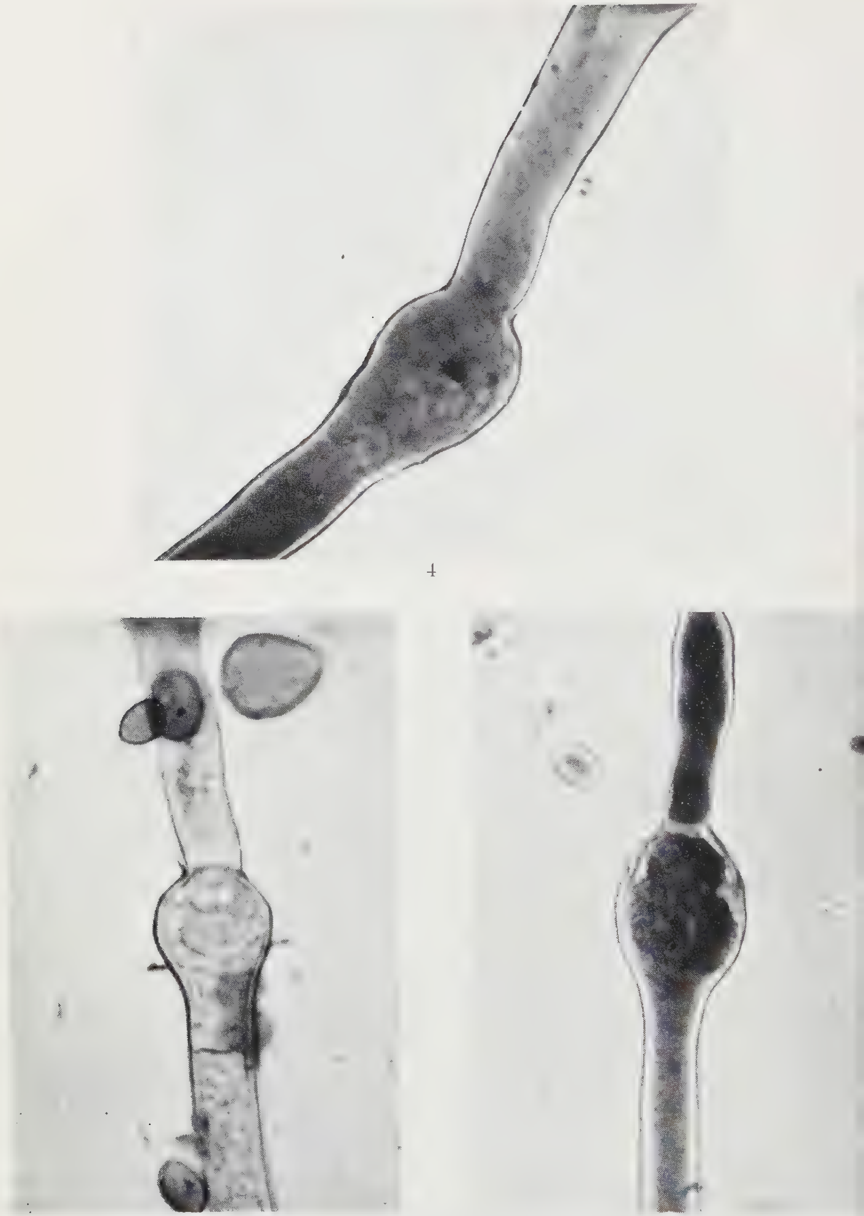
Fig. 1.—A subterminal cell of a conidiophore of *G. highlei* showing the development of intrahyphal growth. × 580.

Figs. 2 and 3.—A lateral prostrate hypha of the mycelium of *G. highlei* showing the presence of an intrahyphal growth in the terminal cell. The growth becomes free from the "parent" cell at (a). Fig. 2. × 500. Fig. 3. × 750.



FIGS. 4, 5, and 6. Proliferation of conidiophores of *G. highlei* brought about by total sept evagination, showing the presence of collars at the bases of the outgrowths. Fig. 4. ×800 Fig. 5. ×600. Fig. 6. ×580.

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ENZYME ACTIVITY IN RELATION TO BARLEY VIABILITY.

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I. INTRODUCTION.

Much of the information available concerning the intimate metabolism of the living seed has come, not from studies of seed metabolism for its own sake, but from empirical investigations of tests of seed viability. It is essential for a grain merchant to know whether his seed is alive or not, and it is not always convenient, or indeed practicable, to carry out straightforward germination tests. Many chemical tests of viability have been proposed; all are more or less useful but none has proved wholly reliable. This is perhaps not surprising, for the germination of a seed is not the result of one simple chemical reaction, but rather the expression of the sum total of an unknown number of incompletely understood biochemical processes. It may well be that there is no single metabolic change which occupies a key place in the mechanism of germination, and which, being invariably the first to be thrown out of action by ageing or by adverse conditions, can thus form the basis of an accurate determination of viability. However, despite the lack of fundamental information on the relative importance of different aspects of the biochemistry of germination, a consideration of certain empirical tests of cereal viability yields useful information concerning metabolic activities in the grain.

One of the earliest methods suggested for artificial assessment of viability (von Quam, 1906, through Brücker, 1948) depends on the measurement of the different amounts of carbon dioxide evolved by resting seeds. The formation of such an end product of respiration is, no doubt, a reasonable criterion of life, but, unfortunately, cereal seeds may harbour an extensive sub-epidermal micro-flora (Hyde, 1950), which may make a substantial contribution to respiration in the living grain and which may survive after the death of the seed. In this connection Bishop (1945) found that samples of barley which had been damaged by heating evolved respiratory carbon dioxide although they were unable to grow.

Instead of determining an end-product of respiration, it should theoretically be possible to measure the activity of individual enzymes catalysing steps in the respiratory cycle: thus, presence of peroxidase (Brücker, 1948) has been suggested as an indication of life in cereals. Bishop, however (1945), found that a peroxidase reaction was regularly given by samples of barley which failed to germinate. Catalase, another enzyme which, like peroxidase, is concerned with the removal of a potentially toxic product of respiration, is also present in many different seeds which have lost all power of germination (Crocker and Harrington, 1918).

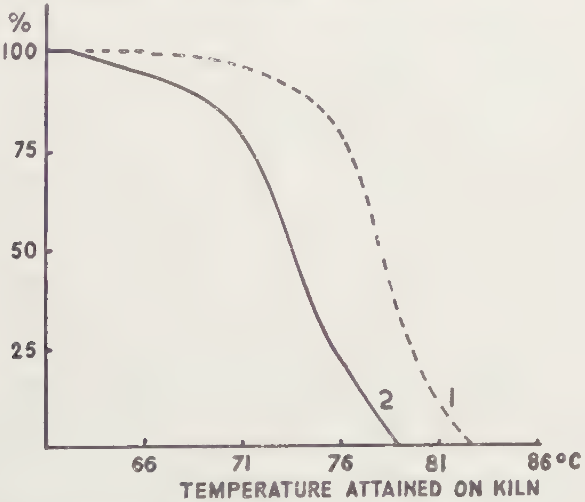

Fig. 1.—Discrepancy between tetrazolium staining and germination. The temperature at which the discrepancy becomes apparent varies in different samples of barley, being influenced by, *e.g.*, the water content of the grain. 1, tetrazolium staining; 2, germination of peeled corns.

Perhaps the most popular rapid methods of assessing viability are those which depend on simple staining reactions. Solutions of salts of tellurium (Müller, 1943), selenium (Eidmann, 1936) and tetrazolium (Lakon, 1942) are all colourless in the oxidised state and coloured in the reduced state; all can penetrate into the living cell where they are rapidly reduced, probably through the agency of dehydrogenating enzymes. Development of a colour in the embryo in presence of one of these compounds has thus been taken as a criterion of viability, and, from the popularity of both sodium biselenite and tetrazolium chloride with practical seed analysts, it is clear that these tests have a considerable degree of reliability. That they are not always wholly reliable is apparent from the work of Crafa *et al.* (1949), Siegfried (1949), Goodsell (1948), and MacLeod (1950). It appears that reduction of tetrazolium chloride, with formation of a red formazan in the embryo, gives a reasonably good estimate of viability in dormant and in ageing cereal seed; with barley which has been damaged by overheating, or with maize which has suffered freezing injury, however, the results obtained with tetrazolium chloride are higher than those achieved on actual germination. Apparently the activity of the enzyme or enzymes responsible for catalysing the colour change is not the only critical metabolic reaction involved in initiating growth of the embryo. As is the case with catalase and peroxidase, the enzyme may, under certain circumstances, retain activity in seeds which are incapable of germination. The lag between loss of germinative capacity and loss of ability to reduce tetrazolium chloride is not great (see fig. 1) and, in practice, samples of seed falling into this critical range will not frequently be encountered, but the discrepancy is there, and the possible reasons for this discrepancy are of considerable theoretical interest.

II. Mechanism of Reduction of Tetrazolium Chloride.

In view of the close parallel between the loss of ability to reduce tetrazolium chloride and the loss of germinative capacity, it is of interest to ascertain the details of this biological reduction. Gunz (1949) has shown that dried yeast and precipitates obtained by addition of alcohol to cell-free extracts of yeast retain the power of reducing tetrazolium salts. Activity of yeast extracts towards tetrazolium chloride is abolished by dialysis but can be restored by addition of glucose and phosphate to the dialysed extract. Jerchel and Mohle (1944) have shown that the apparent redox potential of 2, 3, 5-triphenyl tetrazolium chloride is about −0·08 volts, so that it is theoretically possible for this compound to act as an electron acceptor for many plant dehydrogenases. Dehydrogenases from higher plants are notoriously difficult to extract and, after extraction, often appear reluctant to act with the usual hydrogen acceptors such as methylene blue. However, some measure of success has been achieved in preparing from barley a cell-free extract capable of catalysing the reduction *in vitro* of tetrazolium chloride.

Ground barley was extracted for 2 hours in 2½ vol. of mixed phosphate buffer (pH 7·2) at 37° C. in presence of papain. The high temperature and the papain may be effective in causing enhanced proteolysis and thus facilitating extraction of the enzyme, or, as Sandegren and Klang (1950) have suggested, the SH groups in papain may activate SS groups in extracted enzymes. The mixture was centrifuged to remove starch and cell débris, and the supernatant liquid was incubated at 21° C. in the dark with a 0·1 per cent. tetrazolium chloride solution in presence of toluene. A red colour developed after 8 hours incubation; a control tube in which the barley extract had been boiled to inactivate enzymes showed no colour change. At higher temperatures (25-37° C.), although an initial pink coloration was observed, the reaction did not go to completion with formation of a carmine-red formazan; instead, a brown precipitate was formed. When autolysed yeast—a rich source of the tetrazolium-reducing system—was used in place of barley extract, the reaction went to completion at 37° C., but when the yeast preparation was diluted to one-eighth of its original strength with distilled water, its behaviour resembled that of the barley extract. It seems, therefore, that dilute preparations of the tetrazolium-reducing system are inactivated at higher temperatures before complete reduction can be accomplished.

The extract was buffered at various levels between pH 5·0 and pH 8·5. Two pH optima were observed, one at 7·0 and a second at 7·7. No reduction took place in 16 hours below pH 5·5 or above pH 8. The double pH optimum might be indicative of the participation of two different enzymes in the reaction, each with a separate pH optimum.

In an investigation of the effect of inhibitors on the mechanism catalysing the colour change, it was found that phenyl mercuric nitrate, sodium iodoacetate, and sodium bisulphite inhibited reduction of tetrazolium chloride by barley extracts; urethane and sodium cyanide had no inhibitory effect. Presumably, then, the enzyme system concerned is not a metal-containing catalyst, but rather one whose activity depends on ·SH groupings.

Dialysis of an active extract of ground barley diminished and finally abolished the reducing power of the extract towards tetrazolium chloride. When dialysis was carried out at room temperature, however, bacterial contamination was frequent even in presence of toluene, and, as Kuhn and Jerchel (1941) have pointed out, bacteria can rapidly reduce tetrazolium salts. The presence of bacteria would invalidate any conclusion that might be drawn concerning the reducing power of the barley preparation.

The tetrazolium solution, however, readily penetrates into the bacterial cell, where it is reduced to the formazan, and it has been found in the course of the present work that this formazan cannot be extracted from the intact cell by solvents such as butanol or ether. When barley extract which had reduced tetrazolium was shaken up with ether, the red colour passed into the ether layer, leaving an almost clear aqueous layer below. When reduction was due, not to barley enzymes, but to contaminating bacteria, treatment with ether failed to dissolve the red formazan, and the red colour remained in the lower aqueous layer. Results of all experiments which showed bacterial contamination were discarded. In addition, it was found advisable to prepare dialysed extracts at 4° C.; at this temperature the enzyme system appeared to be more stable, and bacterial growth was minimised.

During dialysis, substrates or co-enzymes (both of low molecular weight) are removed from the extract, and addition of the appropriate substrate and co-enzyme to the extract should restore its activity. A number of theoretically possible substrates were prepared in 0·1 M solution in phosphate buffer at pH 7·0. Two ml. of selected solution and 2 ml. of 1 per cent. tetrazolium chloride were added to 10 ml. of an extract which had been dialysed for 8 hours, and the mixtures were incubated at 21° C. for 16 hours. Observations were made both in presence and in absence of added co-enzyme I, and similar results were obtained in both series (see Table I).

It is clear that glucose, fructose, sucrose, glutamic acid, glycerophosphoric acid, and certain of the participants in the Krebs dehydrogenation cycle, viz., succinic acid, fumaric acid and malic acid, are at last partially effective in restoring activity to the dialysed extract. Similar results were obtained when the extract and added substrates were buffered at pH 7·7, the second pH optimum, and here again no acceleration of reduction was observed in presence of added co-enzyme I. Aspartic acid not only failed to restore activity to dialysed extracts but also inhibited reduction of tetrazolium chloride by extracts which had been dialysed for 1 to 2 hours.

After prolonged dialysis (24–48 hours), activity could not be restored to the dialysed extract by addition of the above-mentioned substrates, either alone or in presence of co-enzyme I, or by addition of boiled undialysed extract.

There can be little doubt that the reduction of tetrazolium chloride by barley extract is catalysed by a dehydrogenase—or dehydrogenases—with pH optima at 7·0 and 7·7. Glucose dehydrogenase with co-enzyme I is known to be effective in reducing tetrazolium salts in presence of glucose (Mattson *et al.*, 1947); this enzyme system is found in mammalian liver and in certain

TABLE I.

EFFECT OF ADDITION OF VARIOUS SUBSTRATES TO DIALYSED EXTRACT.

Substrate added to Dialysed Extract.	Reaction with Tetrazolium Chloride.*
Aspartic acid	No colour
Citric acid	No colour
Fructose	Pink
Fumaric acid	Pink
Glucose	Pink
Glutamic acid	Pale pink
Glycerophosphoric acid	Pink
Lactic acid	No colour
Malic acid	Pink
Succinic acid	Light red
Sucrose	Pink
Boiled undialysed extract	Light red
Control—undialysed extract	Red

* Reactions with tetrazolium chloride were the same in presence or in absence of added co-enzyme I.

fungi, but there does not seem to be any record of its presence in barley embryos. However, James *et al.* (1941) have shown that barley contains a phosphorylating mechanism similar to that found in yeast and in muscle, and capable of converting sugars to pyruvic acid. The efficacy of glucose and other sugars in restoring activity to dialysed barley extracts could be attributed to any one of several dehydrogenases linked up with this process of glycolysis, and dependent for activity on a regular supply of the breakdown products of sugars. Although the presence of several dehydrogenases has been reported from cereal grains (see, *e.g.*, Waygood, 1950), the exact metabolic status of plant dehydrogenases remains somewhat uncertain. Bonner (1947) has suggested that oxidation of pyruvic acid by *Avena* coleoptile involves an organic acid metabolic cycle involving succinic and malic acids, and Laties (1947) has made a similar suggestion for barley. Part of the organic acid cycle known from yeast and from muscle may be represented as:

Succinic $\rightleftharpoons$ Fumaric $\rightleftharpoons$ Malic $\rightleftharpoons$ Oxaloacetic acid (Equation I), the oxidation of succinic acid to fumaric acid requiring the co-operation of succinic dehydrogenase, and that of malic to oxaloacetic similarly requiring malic dehydrogenase. In the living intact embryo, the liberated hydrogen ions reduce co-enzyme I or some other hydrogen acceptor and it seems highly probable that, when tetrazolium chloride is present in the cell, it supplants the natural hydrogen acceptor and is itself reduced to the red formazan. The efficacy of malic acid in restoring activity to dialysed extracts suggests that malic dehydrogenase may be one enzyme capable of utilising tetrazolium chloride as hydrogen acceptor; succinic dehydrogenase may be similarly involved. The effect of aspartic acid in inhibiting reduction is of interest in this connection. Aspartic acid yields oxaloacetic acid on deamination, and formation of oxaloacetic acid would throw the chain of events represented in Equation I to the left; dehydrogenation of succinic and malic acid would then be minimised and reduction of tetrazolium chloride prevented. In animal tissues, moreover, tetrazolium chloride has been used to estimate succinic dehydrogenase activity (Kun and Abood, 1949) and it seems reasonable to assume that organic acid dehydrogenases are similarly involved in reactions catalysed by plant tissues.

If this explanation of the reduction of tetrazolium chloride by barley embryos is correct, then the staining technique is a test, not of "life" in the seed, but of the presence of active organic acid dehydrogenases. Plant dehydrogenases are amongst the most delicate of enzymes, and it is quite possible that they are amongst the first to lose activity in ageing seed; disruption of the respiratory system caused by the breakdown of dehydrogenase systems would almost certainly prove fatal to the plant.

It is interesting to note that Thimann (1950) attributes to these organic acids a major rôle in plant metabolism. From a study of the effects of inhibitors on *Pisum* internodes and on *Avena* coleoptiles he has concluded that protein synthesis, cell-wall synthesis and fat oxidation are all intimately connected with the oxidation of organic acids. Thimann suggests, in fact, that growth may be considered to be a process mediated by oxidation of organic acids.

It seems that the presence of active organic acid dehydrogenases is at least a rough indication of potentiality for growth in cereal embryos. Other enzymes, however, may be of equal importance to the developing seedling, and it would be of interest to determine their activity in relation to the tetrazolium-reducing system and to the onset of growth in the seed.

III. Enzyme Activity in Damaged Grain.

Apart from circumstantial evidence derived from *ad hoc* tests of viability, little is known of enzyme activity in damaged grain, and the few experimental results available are somewhat conflicting. Thus, White (1909) found that wheat which had lost all power of germination through ageing or through overheating retained diastatic and proteolytic activity; Siegel (1950), on the other hand, considered that amylase and proteinase of wheat were readily inactivated by heating the grain and suggested that failure to germinate might result from inadequate supplies of sugars and amino acids normally derived from the activity of these enzymes. His work, however, reveals a certain lack of knowledge of the nature of wheat amylase, and an unwarranted faith in the efficacy of toluene as an antiseptic. Amylase of ungerminated grains is almost entirely β-amylase (Hopkins *et al.*, 1946) and the tests Siegel performed were for α-amylase. He may unwittingly have been investigating the enzyme activity and heat-resistance of the subepidermal fungi of wheat, rather than of the grain itself.

The catalase activity of seeds has been fairly fully investigated. Crocker and Harrington (1918) found no relationship between catalase activity and viability in *Holcus*. Davis, however, (1926) showed that the catalase content of living wheat grains remained constant or increased after soaking at 32° C. overnight, while that of dead seed fell to less than half of the previous level. Apparently, then, catalase may remain active in seeds which cannot grow, though, in the soaked grain, ability to maintain the enzyme, or to form new catalase to replace that destroyed, is lost. Comparative studies of enzymic activity in seeds, however, are lacking, and it seemed desirable to investigate the status of a number of enzymes in different samples of seed of one particular species.

To achieve this, samples of barley which had degenerated through ageing, and samples whose germinative capacity had been lowered and finally abolished through heating, were used for assessment of the activity of a number of enzymes. The ageing samples represented many different varieties, and no data were available as to conditions of storage for the oldest members of the series. Differences in enzyme content may be varietal or seasonal or environmental, and this innate variability must be taken into account when enzyme activity of ageing samples is considered. Heat damage was accomplished by maintaining Spratt-Archer barley in a hot-air oven at 100° C.; samples were withdrawn from the bulk at 15-minute intervals, and were cooled and stored for four weeks before testing.

β-amylase and proteinase activity were estimated by the method of Sandegren and Klang (1950), peroxidase activity was determined by the method of Wallerstein *et al.* (1948) and catalase by the method of Davis (1926). Dehydrogenase activity was assessed by noting the reaction with tetrazolium chloride given by halfed corns (*cf.* MacLeod, 1950), and acid phosphatase by estimation of free phenolic groups liberated from disodium phenyl phosphate (Sumner and Somers, 1943). Chromatographic methods were developed for detection of maltase and invertase activity: ground barley was incubated with the appropriate substrate, and the sugars in aliquots of the reaction mixture taken at 15-minute intervals were separated by paper chromatography. Hydrolysis of maltose to glucose or of sucrose to glucose and fructose, as compared with control experiments with ground boiled barley, was taken as indicative of enzymic activity.

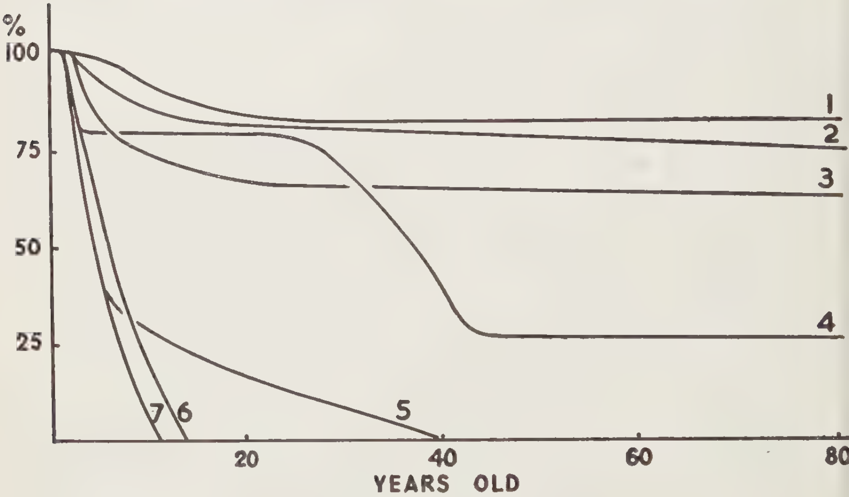

Fig. 2*a*.—Activity of enzymes in ageing barley.

Enzyme activity expressed as percentage of that shown by fully-germinable barley of the 1951 harvest (mean of three samples). 1, proteinase; 2, amylase; 3, phosphatase; 4, catalase; 5, peroxidase; 6, dehydrogenase; 7, germination of peeled corns. 3 samples were available at each of the following ages: 1, 2, 3 and 5 yr.; 2 samples at 10 yr. old and 1 sample at each of the following ages: 17, 25, 39 and 81 yr.

Germinative capacity has been estimated by Bishop's method (1944); this peeled corn technique gives maximum germination and reveals the viability of dormant grains.

Results of these enzyme experiments have been expressed graphically as percentages of the activity in the untreated grain. No figures for enzyme activity have been quoted, since estimates of enzyme activity are frequently based on wholly arbitrary values, and for the present purpose it is felt that trends in enzyme inactivation are more important than absolute levels of activity.

From a consideration of fig. 2*a* it can be seen that, with the ageing samples, amylase, proteinase and phosphatase activity were virtually unaffected by prolonged storage, which amounted to over eighty years in the case of the oldest sample—though no sample over ten years old showed any germination. Catalase activity diminished only slightly in samples up to thirty years old, and then fell more rapidly; even in the oldest samples, however, some slight catalase activity remained. Peroxidase activity fell steeply with diminishing viability though peroxidase was present even in some non-viable corns. As would be expected from studies of tetrazolium salts as indicators of germinative capacity (see, *e.g.* MacLeod, 1950), loss of dehydrogenase activity paralleled loss of viability, though in several instances, figures for germination were much lower than those for presence of active dehydrogenase.

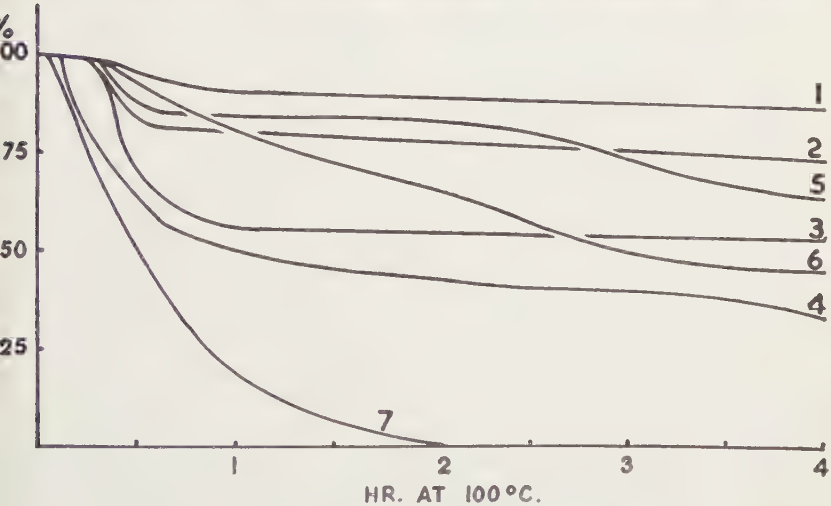

FIG. 2*b*.—Activity of enzymes in heat-damaged barley.

Enzyme activity expressed as percentage of that shown by untreated grain. 1, proteinase; 2, amylase; 3, phosphatase; 4, catalase; 5, peroxidase; 6, dehydrogenase; 7, germination. Determinations were made on samples withdrawn at 15-min. intervals for 2 hr., thereafter at hourly intervals.

With heat-damaged barley (fig. 2*b*), survival of enzyme activity after all power of germination had been lost was even more marked.

All enzymes investigated showed diminished activity after two hours heating, but none was wholly inactivated; it is thus clearly impossible to equate the presence of any of the enzymes investigated with ability to germinate. Maltase and invertase are not shown in fig. 2; maltase activity was detected in all samples of barley investigated and invertase activity in none of them.

It may be of some interest to consider the results of this fundamental investigation of enzyme inactivation in relation to empirical tests of viability. The enzymes which have been used to assess viability, viz. dehydrogenases and peroxidase, show decreasing activity with falling germinative capacity in ageing barley. In practice, the marked discrepancy between peroxidase content and viability at levels below 25 per cent. germination is of little significance, and does not lessen the utility of the peroxidase reaction for seed-testing; farmers or maltsters intent on purchasing grain would have no interest in material with a very poor power of germination, and would be unconcerned at the inaccurate results given by such samples. With heat-damaged barley, however, the discrepancy between germinative capacity and peroxidase and dehydrogenase activity is very greatly increased; the effect of the heat-treatment has been further to dissociate viability from the activity of the enzymes investigated. The lag between loss of germinative capacity and inactivation of peroxidase, so marked in the old samples of the "ageing" series, is apparently exaggerated by heat-damage. This lag suggests a ready explanation of the occasional failure of viability tests based on dehydrogenase or peroxidase activity.

At first sight, catalase would seem to be a potentially useful enzyme for assessing germinative capacity (see figs. 2*a* and 2*b*). It must be remembered, however, that the innate variability of catalase content in seeds is high, and that, owing to a residual catalase activity in non-germinable grains, a "presence or absence" test is not practicable.

In view of the results obtained by Davis (see p. 25) it would clearly be of interest to determine the activity of certain of these enzymes in barley before and after steeping at a moderately high temperature. Determinations involving the use of ground barley are not suitable for such work, as difficulties would be encountered in achieving evenness of grinding with all samples, whilst the previously mentioned associated microflora might contribute extensively to the apparent enzymic activity of the grain. However, the dehydrogenase test (tetrazolium staining) is suitable as it is carried out with half corns, and fungal or bacterial action can be detected by visual examination.

Accordingly, samples from untreated barley (100 per cent. reduction of tetrazolium chloride, 100 per cent. germination) and from barley which had been heated for 4 hours (50 per cent. of embryonic region reduced tetrazolium; 0 per cent. germination) were steeped in water at 37° C. Fifty corns were withdrawn from each sample after 16 hours steeping, and 50 more after 40 hours. All four sets of corns were tested with tetrazolium, with the results shown in Table II. At this high temperature, only 21 per cent. of the dehydrogenase activity of fully germinable corns, compared with 88 per cent. of the activity of the heat-damaged sample, was destroyed as a result of maintenance in water for 40 hours.

Table II.

Effect of Steeping at 37° C. on Dehydrogenase Activity of Barley.

	Percentage Embryonic Region Stained.*	
	Fully-viable Barley.	Non-viable Barley.
Unsteeped . . .	100	50
16 hr. at 37° C. . .	95	44
40 hr. at 37° C. . .	79	6
Percentage dehydrogenase inactivated after 40 hr. at 37° C. . . .	21	88

* Mean of three sets of observations.

IV. General Discussion.

When the results reported in Part III are considered in conjunction with those of Part II and with the body of information available on cereal viability, certain interesting points emerge. It is clear that many of the enzymes which are potentially active in stored seeds retain virtually unimpaired activity long after the seed has lost all power of growth; such enzymes include amylase, proteinase, maltase and phosphatase. These enzymes might be said to be digestive in nature, their function being, not to catalyse the reactions characteristic of "life" in the seed, but rather to supply ancillary substances which are later utilised in the respiratory and synthetic processes characteristic of the living cell. Thus, proteolytic enzymes hydrolyse reserve proteins to amino acids, which may be built into the living protoplasm of the seedling—possibly, if Virtanen's theories (1942) are correct, principally into the enzyme complement of the cells. Similarly, acid phosphatase may release PO_4 ions which are involved in many different stages of cell metabolism (see *e.g.*, Baldwin, 1947). It is proposed that this group of enzymes be called "special metabolic enzymes" to indicate their participation in one rather limited aspect of the metabolism of the seedling. Of the other enzymes which have been investigated, two, catalase and peroxidase, are concerned with breakdown of hydrogen peroxide, and one—or one group—the dehyrogenases, is concerned with the maintenance of a respiratory cycle, certainly in animal and probably in plant cells. These are among the "general metabolic enzymes" of the cell; and their presence must be deemed directly essential to the functioning of the cell as a living unit. It seems probable that the presence of active dehydrogenase is a pre-requisite of life in embryos; in rare instances, results given by tetrazolium staining (*i.e.*, tests for presence of dehydrogenase) are statistically lower than those achieved on actual germination of the seeds, but, in all cases investigated, all *germinated* seeds were fully capable of catalysing the reduction. It would appear then, that, very occasionally, the power of synthesising dehydrogenase is retained in seeds which are virtually depleted of active enzyme. The *locus* of respiratory enzyme activity in the cells would appear to be those much disputed cytoplasmic inclusions, the mitochondria (Bourne, 1951). Mitochondria, and the related respiratory enzymes, are rather readily affected by adverse conditions, and the reasonably close parallel between loss of dehydrogenase activity and impairment of germinative capacity is thus not unexpected. However, dehydrogenases can remain active in many samples of barley which fail to germinate (see fig. 2, p. 27; also MacLeod, 1950), and some other explanation of this failure must be sought.

In this connection the results obtained when barley was soaked in water ar 37° C. are of interest. As was the case in work with catalase (Davis, 1926), dehydrogenases of non-viable barley are much more readily destroyed at higher temperatures than are those of living barley. There is no reason to suppose that enzymes are immune from proteolytic digestion, and proteinases appear to be active in non-viable barley. It would appear, therefore, that in certain types of dead barley either the distribution of dehydrogenases in the cell is affected so that they are unduly exposed to proteolysis in the imbibed grain, or that the synthetic capacity of the cell is disorganised so that no further supply of the enzyme is synthesised to replace that normally destroyed by proteolysis. The first suggestion—physical disarrangement of the enzymes within the cell—does not as yet lend itself to ready discussion; though much information is available concerning the behaviour of enzymes *in vitro*, the study of enzymes in action in the living cell is still in its infancy, and it would be idle to speculate on the possible results of hypothetical changes in their distribution. The second suggestion —impaired synthetic capacity in the damaged cell –is, in some ways, an attractive one, though once again information on the vital matter of protein synthesis is discouragingly meagre.

However, it is known that in wheat, and probably in other cereals, considerable changes take place in the nitrogenous constituents during storage. Jones and Gersdorff (1941) have shown that, after two years' storage, protein content falls with a corresponding increase in amino nitrogen, the change being more marked when grain is stored at a higher temperature. It would seem that the dynamic equilibrium of balanced synthesis and degradation has here shifted in favour of increased degradation; such an alteration in the balance of enzyme activity suggests that the synthetic capacity of the cell would be the first to fail in ageing seed. That one type of synthesis is indeed affected by ageing is shown by the work of Gustaffson (1937), who found that higher proportions of albino seedlings were formed from ageing samples of barley. Failure to synthesise chlorophyll is, of course, much more easily detected than failures in enzyme synthesis, but it is possible that both may be aspects of a more widespread phenomenon, dependent, possibly, on impaired gene action.

To sum up, then, it may be said that in ageing barley and in barley which has been progressively damaged by heating, capacity for germination is lost before any of the "special metabolic enzymes" are inactivated, whilst in overheated barley even the general metabolic enzymes largely survive the death of the seed. These two types of injury may not, of course, act on the seed in precisely the same way, though the well-known time-temperature formula of Groves (1917) suggests that heat damage and ageing are two aspects of the same process. It is clear, however, that inactivation of enzymes—even of the group of enzymes most favoured for assessment of viability, the dehydrogenases—cannot usually be invoked as a cause of death, though destruction of certain enzymes follows more or less rapidly after death. Not until a fuller understanding is achieved of the intracellular functioning of enzymes, and of the methods by which the nucleus controls synthesis of proteins, including enzymes, can a more complete picture be given of metabolism in the seed.

It must be remembered, too, that the enzyme complement of a living cell represents an ordered series of inter-connected systems and not an aggregate of individuals. Studies on the action of purified enzymes are valuable in that they suggest the intracellular function of the enzyme, but even more valuable to the biologist would be an understanding of the *organisation* of the individual units into the complex framework of the living cell.

It is realised that much of the argument presented in this discussion represents a personal point of view and that other interpretations of the results quoted above may be possible. It is hoped, however, that the suggestions here put forward may arouse some discussion and perhaps suggest different lines of investigation of what remains a virtually unsolved problem—the nature of the biochemical changes accompanying senescence in seeds.

ACKNOWLEDGMENTS.

Thanks must be expressed to Mr. K. Gleeson for carrying out certain of the analyses of enzyme activity in ageing barley, and to Professor I. A. Preece, Heriot-Watt College, Edinburgh, for much valuable advice during the course of the investigation.

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DIAPENSIA LAPPONICA L. IN SCOTLAND.

By J. GRANT ROGER.
(The Nature Conservancy, Edinburgh.)

(With Plate III.)

(Read 13th December 1951.)

On 5th July 1951 Mr. C. F. Tebbutt discovered *Diapensia lapponica* L. at an altitude of *c.* 2500 feet on hills overlooking Glenfinnan in the Arisaig district of Inverness-shire. This remarkable find, adding, as it did, a new species, genus and family to our records of the British Flora, very soon encouraged others to follow in the steps of Mr. Tebbutt, and, in the following month, several hundred specimens of the plant were observed in the same locality by Messrs. B. L. Burtt, D. M. Henderson, J. E. Raven and the writer.

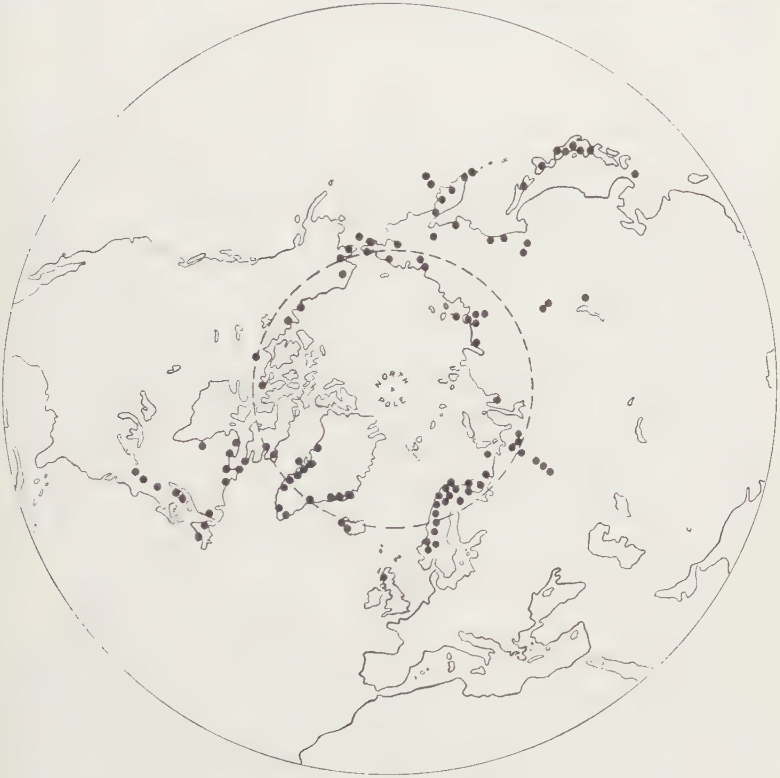
DESCRIPTION

This dwarf shrub grows in small tussocks 1 to 4 inches in height, with persistent crowded, mostly opposite, entire, narrowly spatulate leaves about ½ inch long. The flowers, which appear in June and July, are solitary on a peduncle of 1 to 1¼ inches in height. There are three bracts under the calyx, which has five leathery sepals. The white, campanulate, five-lobed corolla is from ⅓ to ⅔ inch wide, the petals being rounded. Adnate to the corolla, and alternate with the petals, are five stamens bearing two-celled anthers which open by longitudinal slits. The pollen is simple. Three superior carpels form a trilocular ovary with a simple style and slightly three-lobed capitate stigma. The ovules are on axile placentae. No hypogynous disc is present. The fruit is capsular, enclosed in the calyx, and there are a few seeds (with abundant endosperm) in each of the three chambers.

The subspecies *obovata* (Fr. Schm.) E. Hultén (1948), of N.E. Asia and N.W. America, has broader, reticulated leaves and longer petioles, and is considered by Hultén to be a geographical race of *D. lapponica.*

General Distribution

Dr. Eric Hultén, in his splendid *Atlas of the Distribution of Plants in N.W. Europe* (Stockholm, 1950), places *Diapensia lapponica* among his Circumpolar, Arctic-montane plants, which are absent from the mountains of Central Europe, but which have a continuous distribution in northern Siberia. In this group of thirty-seven species Hultén includes also our British *Carex saxatilis* L., *Saxifraga rivularis* L., *Luzula arcuata* Wahlenb., and *Koenigia islandica* L., and those species fall very naturally within the Arctic-Subarctic Element, distinguished by Professor J. R. Matthews (1937).



General distribution of *Diapensia lapponica* L.

The main type of the species (as distinct from the subspecies *obovata*) is found in Iceland, Scandinavia (south to about 60° N. and ascending to 1600 m. in the mountains), Lapland, Kanin Peninsula, Kolguev, the Ural Mountains from 68° N. southwards to *c.* 60°, and the Gydanski Peninsula. In America the main type is found from west of Hudson Bay over East Baffin Land and Labrador to Newfoundland; also on the east side of Hudson Bay, then south-eastward to Quebec, the New England States and New York. In West Greenland it occurs to about 72° N. and in East Greenland to about 70° N.

The subspecies *obovata* is found in North Asia from the mouth of the Khatanga River and the Lake Baikal region eastward to the Chukotski Peninsula, Kamchatka, the Commander Isles, Japan and Quelpart Island; in America it ranges from Alaska to the lower Mackenzie River.

HABITAT

Over much of its geographical range this species seems to prefer exposed rocky and gravelly places and certainly it is well adapted to withstand severe climatic conditions. In its Scottish habitat it is found at *c*. 2500 feet, completely exposed, on schists of the Moine series, which are traversed by bands of pegmatite. Around the cushion-like tufts of *Diapensia* are stones and gravel, broken by the frosts and gales from the rocks which protrude over this wind-swept area. Here the annual rainfall reaches as much as 120 inches, but the drainage is unhindered.

Among the associated plants are *Loiseleuria procumbens* (L.) Desv., *Antennaria dioica* (L.) Gaertn., *Juncus trifidus* L., *Festuca ovina* L., *Juniperus sibirica* Burgsd., and *Rhacomitrium lanuginosum* (Hedw.) Brid.

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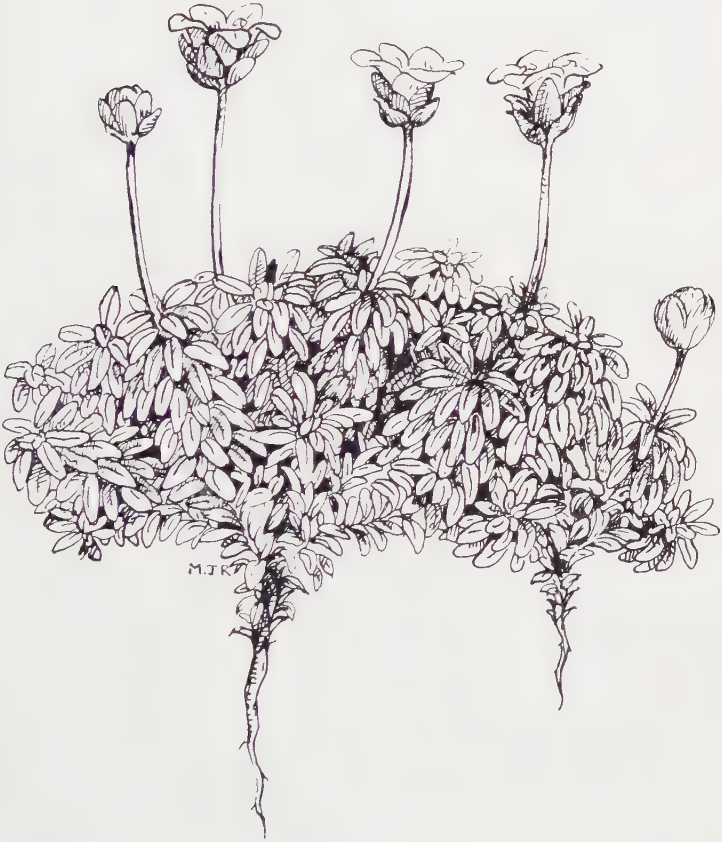

Diapensia lapponica L., from a Scottish specimen.

THE PHYTOPLANKTON OF SOME LOCHS IN SOUTH UIST AND RHUM.

By EDNA M. LIND.
(Botany Department, University of Manchester.)*

(Read by title, 21st January 1952.)

Along the western seaboard of the British Isles there is often a low fringe of calcareous sand blown over the seaward margin and abutting on to the ancient rocks covered by moorland. This calcareous and sandy fringe is the "machair" of the Western Highlands and Islands. There are numerous small pools along the boundary between machair and moor which commonly show great diversity of vegetation and often corresponding differences in the phytoplankton they contain.

A description of some of these lakes in Western Ireland has already been given (Pearsall and Lind, 1942), and the following notes refer to a series in the Hebrides, from which collections were made in August 1946 by Professor W. H. Pearsall. The areas investigated lie in the island of Rhum, and in South Uist just north of a line drawn from Loch Eynort west to the point of Rhuda Ardvule.

SOUTH UIST LOCHS.

In the part where the samples were taken, the machair is about half a mile wide, and to the east of it there lies, for the most part, a low and undulating mass of siliceous archaean rock now almost covered by moorland and bog. The innumerable small lochs often show signs of the heavy glaciation which the island experienced, their margins being either smoothed by ice or littered with the stones and boulders dropped by the ice-sheets. Some of the lochs lie among the calcareous sands and cultivated pastures of the machair; others are surrounded by moorland and bog; while a few lie among developing bogs with their margins composed of deep peat. The lochs from which collections were taken include samples of each of these three extremes as well as of some intermediate types, and some at a higher altitude.

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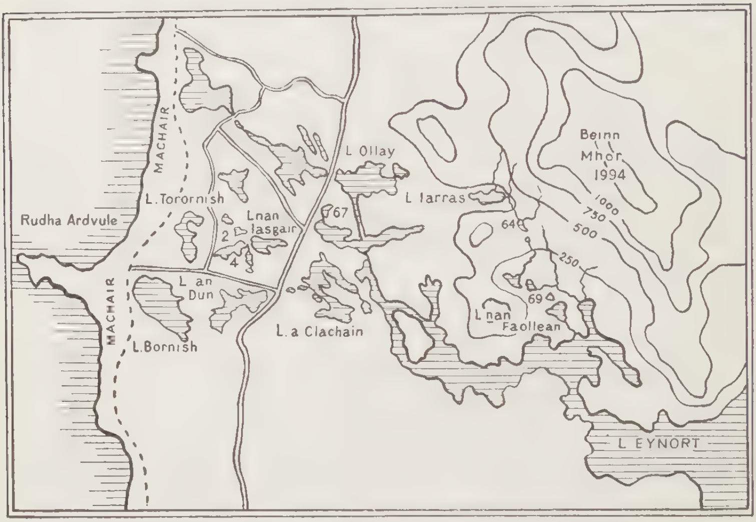
The upland series was collected at between 200 and 400 feet, on a broad and boggy shoulder which runs out to the south-west of Beinn Mhor. Of these lochs, L. Iarras (J) and Loch 64 were probably less "peaty" than L. Ollay and L. a'Clachain, as both had one steep side giving soil drainage. Both were much overgrown by phanerogamic vegetation. L. nan Faollean (62) resembled L. a'Clachain, though at a higher altitude.



SKETCH MAP SHOWING POSITION OF S.UIST LOCHS.

The extreme type of loch is undoubtedly Loch 69, which had deep peat margins (below the water) and was surrounded by quaking bog. Loch 67 was similar in appearance and with almost coffee-coloured water. This was a peat-enclosed arm of a larger moorland loch (Ceann a'Bhaigh) but, unlike Loch 69, was nearly at sea-level.

Description of Lochs and Plankton.

Group 1. *Machair Lochs*: L. Torornish, L. Bornish.

These two machair lochs are surrounded by sandy soil either cultivated or bearing calcareous grassland. Although situated near the sea, their water is not salty, but the presence in the lochs of calcareous sand influences their vegetation. Prominent among the submerged plants are *Chara fragilis* and linear-leaved species of *Potamogeton*, while *Litorella* is present on the shore.

PLANKTON.

The most abundant species common to both lochs are *Eudorina elegans*, *Botryococcus Braunii*, *Ceratium hirundinella* and *C. cornutum*. The desmid *Closterium aciculare* var. *subpronum* is confined to these two lochs, but desmids are not conspicuous. These lochs show some resemblance to those lakes in Western Ireland which are influenced by sea sand, but a notable difference is the absence from the Scottish lochs of *Staurastrum gracile*.

Loch Torornish contains abundant *Nostoc* and filamentous Chlorophyceae and only very few individuals of most plankton species.

Group 2. *Intermediate Lochs*: L. an Dun, L. nan Iasgair, Loch 4, Loch 2.

All these lochs lie at a slightly higher level than those of Group 1, with little or no sign of marine sand or calcareous influence. Apart from Loch 2, which is entirely surrounded by *Agrostis-Festuca* grassland, these lochs lie in an area of mixed heath and machair and receive some drainage from a *Scirpus* bog. There is, therefore, more peaty influence than in Group 1.

Loch an Dun is a largish loch with its margin half rocky, half gravel. The flora includes *Litorella*, *Lobelia*, *Isoetes*, *Myriophyllum spicatum*, and *Phragmites*. Loch nan Iasgair is similar, but without *Phragmites* and with *Cladium marisceus* in addition. Loch 4, on granitic sand, is colonised by *Lobelia*, *Equisetum limosum*, *Sparganium minimum*, and Loch 2 by *Naias* and *Myriophyllum alternifolium*.

PLANKTON.

Eudorina elegans dominant. *Botryococcus Braunii* more abundant than in Group 1. Desmids more abundant and varied. Diatoms few. Myxophyceae common. *Ceratium hirundinella* in all, *C. cornutum* in two. Loch 2 differs from the rest in the greater abundance of Myxophyceae and Chlorophyceae and in the scarcity of *Botryococcus*.

Group 3. *Moorland Lochs.*

(*a*) Low altitude: L. a'Clachain, L. Ollay, L. nan Faollean. Loch a'Clachain is a large loch wholly surrounded by moorland, L. Ollay is a large stony loch at sea-level with little vegetation, and L. nan Faollean is a small loch near the north shore of L. Eynort, surrounded by bog and somewhat above sea-level.

PLANKTON.

Eudorina elegans scarce or absent. Desmid flora largely made up of a few species, *Staurastrum curvatum* var. *inflatum*, *S. gracile* forma *major* and *S. paradoxum*. *Ceratium hirundinella* abundant except in L. a'Clachain.

(*b*) Higher altitude (200–400 ft.): L. Iarras, Loch 64. These lochs are surrounded by *Scirpus* bog, but with one steep slope giving soil drainage. They are much overgrown by phanerogamic vegetation, which includes *Lobelia*, *Castalia*, *Juncus supinus* and *Litorella*.

PLANKTON.

In general rather like Group 2, but *Ceratium hirundinella* plentiful and *C. cornutum* absent. Desmid flora more rich and varied.

Group 4. *Bog Lochs*: Loch 69, Loch 67 (Clarke's Loch).

Loch 69 contains much *Batrachospermum*; Loch 67 is colonised by *Potomageton polygonifolius* and by filamentous algae.

PLANKTON.

Eudorina elegans absent and other Chlorophyceae infrequent. *Ceratium* species infrequent. Diatoms and Myxophyceae few. Desmids represented mainly by *Closterium* spp. and *Staurastrum gracile* forma *major*. These lochs, surrounded by growing bog and with no soil drainage, are very poor in species.

LOCHS ON RHUM.

Three samples from the island of Rhum are described.

Loch a'Ghille Reamhre: This lies amongst moorland but with a considerable rocky slope to the west. Much *Lobelia* was present.

PLANKTON.

Desmids represented mainly by *Gonatozygon monotaenium*. No species of *Staurastrum*. *Ceratium* species absent.

Loch Gainmhich and Loch Mhic Neill: These two lochs are at a higher level with rather sandy and boulder-strewn shores and are of interest because they drain from the unusual ultra-basic rocks found on Rhum. These rocks have iron and magnesium as the principal bases, and it was thought that the plankton might be unusual. In this respect they were disappointing.

PLANKTON.

Composed mainly of diatoms, *Botryococcus* and *Ceratium* species. These were the only lochs on either island which had *Asterionella*.

Additional Species.

In addition to those recorded in Table I as occurring in two or more lochs, the following species were observed in the lochs indicated. For the names of the lochs (where known) see Table I.

Chlorophyceae (General)	
Coelastrum cambricum Archer	1.
Gloeocystis planctonica (Näg.) Lemm.	A.
Chlorophyceae (Desmids)	
Closterium abruptum West	67.
angustatum Kütz.	C.
gracile Bréb.	69.
juncidum Ralfs.	67.
var. elongatum Roy & Biss.	67.
Kützingii Bréb.	4.
parvulum Näg.	69.
toxon West	69.
Tetmemorus granulatus (Bréb.) Ralfs.	64.
Euastrum bidentatum Näg.	69.
gemmatum Bréb.	C.
Micrasterias papillifera Bréb.	1.
Cosmarium margaritiferum Menegh.	J.
orthostichum Lund.	64.
pseudoconnatum Nordst.	C.
punctulatum Bréb.	64.
pyramidatum Bréb.	64.
rectangulare Grun.	64.
reniforme (Ralfs) Arch.	64.
sexnotatum Gutw.	64.
subtumidum Nordst.	J.
Xanthidium cristatum Bréb.	1.
Arthrodesmus triangularis var. subtriangularis, W. & G. S. West	1.
Staurastrum Arachne Ralfs.	C.
Bienneanum Rabenh.	C.
aristiferum Ralfs.	C.
corniculatum var. spinigerum West	4.
ellipticum West	B.
furcigerum Bréb.	A.
megacanthum var. Scoticum W. & G. S. West	C.
muticum Bréb.	1.
Ophiura Lund.	64.
Desmidium coarctatum Nordst.	64.
Dinophyceae	
Dinobryon bavaricum Imhof.	C.

TABLE I.

Species.	S. UIST.													RHUM.		
	Machair.		Intermediate.				Upland.		Moorland.			Bog.				
	L. Torornish.	L. Bornish.	L. an Dun.	L. nan Iasgair.			L. Iarras.		L. Ollay.	L. nan Faollean.	L. a'Clachain.	Clarke's Loch.		L. a'Ghille Reamhre.	L. Gainmhich.	L. Bealach Mhic Neill.
	3	A	B	1	2	4	J	64	60	62	C	67	69	45	46	2
CHLOROPHYCEAE (general).																
Eudorina elegans Ehrenb.	× × ×	× × ×	× × ×	× × ×	× ×	× × ×	× × ×	×	× ×	. .	. .	. .	. .	. .	. .	×
Sphaerocystis spp.	. .	. .	×	×	× ×	. .	. .	. .	× × ×	× ×	. .	. .	. .	. .	× ×	×
Pediastrum Boryanum (Turp) Menegh.	×	×	×	×	× ×	×	× ×	. .	. .	. .	. .	. .	. .	× ×	×	. .
Crucigenia rectangularis A.Br.	×	. .	×	. .	× ×	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .
Botryococcus Braunii Kütz.	×	× ×	× ×	× × ×	×	× × ×	. .	× ×	×	× ×	×	× ×	. .	. .	. .	× × ×
protuberans W. & G. S. West	. .	. .	. .	. .	. .	. .	× × ×	× ×	. .	. .	. .	. .	. .	. .	. .	. .
Quadrigula lacustris Chodat.	. .	. .	. .	×	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .
CHLOROPHYCEAE (desmids).																
Gonatozygon monotaenium De Bary	. .	. .	× ×	× ×	. .	. .	. .	. .	. .	. .	. .	. .	. .	× × ×	×	. .

Closterium aciculare var. *subpronum* West	×	×	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	. .
intermedium Ralfs	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	×	. .	. .	. .
setaceum Ehrenb.	. .	. .	×	. .	. .	. .	× ×	×	. .	. .	. .	×	× ×	×	. .	. .
Ulna Focke	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	×	× ×	. .	. .	. .
Pleurotaenium coronatum (Bréb.) Rabenh.	. .	. .	. .	. .	. .	×	× ×	×	. .	. .	. .	. .	. .	. .	. .	. .
Ehrenbergii (Bréb.) De Bary	. .	. .	. .	. .	. .	. .	. .	× ×	. .	. .	×	. .	. .	. .	. .	. .
Trabecula (Ehrenb.) Näg.	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .
Euastrum ansatum Ralfs	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	×	. .	×	× ×	. .	×
verrucosum Ehrenb.	. .	. .	× ×	×	×	. .	×	× ×	. .	. .	×	. .	. .	. .	. .	. .
Turneri West	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	×	. .	. .	. .
Micrasterias denticulata Bréb.	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	×	. .	. .	. .
apiculata Menegh. (Ehrenb.)	. .	. .	×	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .	. .
radiata Hass	. .	. .	×	×	. .	. .	×	× ×	. .	. .	. .	. .	. .	. .	. .	. .
Sol (Ehrenb.) Kütz.	. .	. .	. .	. .	. .	×	×	×	. .	. .	. .	. .	. .	. .	. .	. .
pinnatifida (Kütz.) Ralfs.	. .	. .	×	×	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
truncata (Corda) Bréb.	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	×	. .	. .	. .	. .	. .
Cosmarium Botrytis Menegh.	. .	×	. .	×	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .
connatum Bréb.	. .	. .	. .	. .	. .	×	. .	×	. .	. .	. .	. .	. .	. .	. .	. .
contractum Kirch.	. .	. .	×	× ×	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	×	. .
depressum (Näg.) Lund	×	×	×	×	×	× ×	×	× ×	×	. .	. .	. .	. .	. .	. .	. .
margaritatum Menegh.	. .	. .	. .	. .	. .	. .	. .	× ×	. .	. .	×	. .	. .	. .	. .	. .
moniliforme (Turp.) Ralfs.	. .	× ×	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .
reniforme (Ralfs.) Arch.	. .	. .	. .	. .	. .	×	×	. .	. .	. .	. .	. .	. .	. .	. .	. .
Xanthidium antilopaeum (Bréb.) Kütz.	. .	. .	× ×	× ×	× ×	× ×	×	×	×	×	× ×	. .	. .	× ×	. .	. .
Arthrodesmus Incus (Bréb.) Hass.	. .	. .	×	×	. .	× ×	×	×	. .	. .	. .	. .	. .	. .	. .	. .
Staurastrum Arctiscon (Ehrenb.) Lund.	. .	. .	. .	×	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .	. .
anatinum & vars. Cooke & Wills	. .	. .	× ×	×	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .

TABLE I—*continued.*

Species.	S. UIST.													RHUM.		
	Machair.		Intermediate.				Upland.		Moorland.			Bog.				
	L. Torornish.	L. Bornish.	L. an Dun.	L. nan Iasgair.			L. Iarras.		L. Ollay.	L. nan Faollean.	L. a'Clachain.	Clarke's Loch.		L. a'Ghille Reambre.	L. Gainmhich.	L. Bealach Mhic Neill.
	3	A	B	1	2	4	J	64	60	62	C	67	69	45	46	2
CHLOROPHYCEAE (desmids)—(*continued*).																
Staurastrum curvatum West	..	× ×	×	..	×	..	..	..	..	..	..	..	..	..	..	..
var. *inflatum* (nobis) .	..	..	..	..	..	..	×	..	× × ×	× ×	×	..	..	..	..	..
cuspidatum Bréb. . .	..	..	×	..	×	..	..	..	×	..	..	..	..	..	..	..
brevispinum, Bréb. . .	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..
var. *altum* W. & G. S. West	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..
gracile, forma major, nobis *	..	..	..	..	..	..	×	× ×	× × ×	× ×	..	×	×	..	..	..
var. *cyathiforme* W. & G. S. West. . .	..	..	× ×	..	× ×	×	×	×	×	..	..	..	..	..	×	..
jaculiferum West . .	..	× ×	×	..	..	..	..	..	..	..	×	..	..	..	..	..
lunatum var. *planctonicum* West	..	× × ×	×	..	× ×	..	..	..	..	..	..	..	..	..	..	..

Staurastrum laevispinum Biss.	. .	. .	. .	×	. .	× ×	×	. .	. .	. .	×	. .	. .	. .	. .	. .
longispinum (Bail.) Arch.	. .	. .	. .	×	. .	. .	. .	× ×	. .	. .	. .	. .	. .	. .	. .	. .
Manfeldtii, var. *annulatum* West	×	× ×	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .	. .
paradoxum Meyen & vars.	. .	×	×	. .	×	×	×	. .	. .	. .	× × ×	. .	. .	. .	. .	. .
sexangulare (Bulnh.) Lund.	. .	×	×	× ×	×	× ×	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
vestitum West	. .	. .	. .	×	×	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Sphaerozosma Aubertianum West	. .	. .	×	×	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .
excavatum Ralfs.	. .	. .	. .	. .	. .	. .	×	×	. .	. .	. .	. .	. .	. .	. .	. .
Hyalotheca dissiliens (Sm.) Bréb.	. .	. .	× ×	× ×	. .	×	×	. .	. .	. .	×	. .	. .	. .	. .	. .
mucosa (Mert.) Ehrenb.	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	×	. .	. .
Cosmocladium pulchellum Bréb.	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	. .
Gymnozyga moniliformis Ehrenb.	. .	. .	. .	× ×	. .	. .	× × ×	× × ×	. .	. .	. .	. .	. .	. .	. .	. .
BACILLARIOPHYCEAE.																
Tabellaria flocculosa (Roth.) Kütz.	× ×	. .	×	× ×	. .	×	×	×	×	×	× ×	. .	. .	× ×	× ×	× × ×
fenestrata (Lyngb.) Kütz.	. .	. .	. .	×	. .	. .	× ×	×	. .	. .	× × ×	× ×	×	× ×	×	× ×
Asterionella formosa Hassal.	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	× ×	× ×
MYXOPHYCEAE.																
Aphanothece nidulans, P. Richter	. .	×	×	. .	. .	×	×	×	×	. .	×	. .	. .	×	. .	. .
Aphanocapsa delicatissima W. & G. S. West	. .	× ×	×	× ×	× × ×	×	. .	. .	. .	. .	. .	. .	. .	×	. .	. .
elachista West	×	. .	. .	× ×	× ×	×	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Anabaena Lemmermannii P. Richter	. .	× ×	. .	× ×	× ×	. .	×	. .	× ×	. .	×	. .	. .	. .	× ×	. .
Chroococcus limneticus Lemm.	. .	× × ×	. .	×	× × ×	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .
Coelosphaerium Kützingianum Näg.	. .	. .	×	. .	× ×	×	. .	×	. .	. .	×	. .	. .	. .	. .	×
Microcystis incerta Lemm.	. .	× ×	. .	. .	× ×	× ×	. .	. .	× ×	×	. .	. .	. .	. .	. .	. .

* See Lind and Pearsall (1944).

Table I—*continued.*

Species.	S. Uist.													Rhum.		
	Machair.		Intermediate.				Upland.		Moorland.			Bog.				
	L. Torornish.	L. Bornish.	L. an Dun.	L. nan Iasgair.			L. Iarras.		L. Ollay.	L. nan Faollean.	L. a'Clachain.	Clarke's Loch.		L. a'Ghille Reamhre.	L. Gainmhich.	L. Bealach Mhic Neill.
	3	A	B	1	2	4	J	64	60	62	C	67	69	45	46	2
Dinophyceae.																
Ceratium hirundinella O.F.M.	×	× ×	× × ×	×	× × ×	×	×	× ×	× × ×	× × ×	. .	×	. .	. .	× × ×	× × ×
cornutum (Ehrenb.) Clap. & Lachm.	×	×	. .	× × ×	. .	× ×	. .	. .	. .	. .	×	. .	. .	. .	×	. .
Peridinium Willei Huitf. Kaas.	. .	. .	× ×	× ×	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Chrysophyceae.																
Dinobryon divergens Imhof.	. .	. .	. .	. .	. .	. .	. .	. .	× × ×	. .	. .	. .	. .	. .	× ×	× ×

SUMMARY.

Although the lochs described differ in appearance, size, and in the nature of their surroundings, they show little individuality in regard to the composition of their summer plankton. Apart from the influence of blown sand, the type of water is probably very uniform and the effect of bog drainage is felt in differing degree in all the lochs under consideration. All are relatively poor in plankton species.

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THE DISTRIBUTION, HOST RANGE AND SEASONAL DEVELOPMENT OF PUCCINIA GRAMINIS PERS. IN SOUTH-EAST SCOTLAND.

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(Edinburgh and East of Scotland College of Agriculture, Edinburgh.)*

(With Plate IV.)

(Read by title, 21st February 1952.)

In the late summer of 1945 many reports were received of severe attacks of black rust, *Puccinia graminis* Pers., on cereals in the Border counties of Scotland and it soon became apparent that the rust could do serious damage. Observations on the fungus in all its stages in south-east Scotland were therefore begun that year and were continued for four years. The south-east area is naturally divided into two parts, one north of the Firth of Forth, consisting of the counties of Perth (East), Kinross, Angus and Fife, and one south of the Forth comprising the counties of the Lothians, Peebles, Selkirk, Roxburgh and Berwick.

OCCURRENCE ON BERBERIS AND MAHONIA.

(*a*) On *Berberis*

Most floras of south Scotland contain notes on the occurrence and distribution of the common barberry, *Berberis vulgaris* L. It is particularly frequent in the Border counties. Text-fig. 1 shows the distribution of the shrub south of the Forth. Each spot on the map represents a barberry locality, which may be anything from a solitary bush to a solid barberry hedge up to four hundred yards long. Barberries are particularly numerous in Roxburghshire, but in general, if land over 1000 feet is excluded, it can be said that there is no field farther than seven miles from a barberry. North of the Forth (text-fig. 2) the barberry is much less frequent. There are scattered bushes around the southern coastal strip of Fife and a few about the town of Perth. Otherwise the plant is rare.

In the years under observation, very few of the barberries in south-east Scotland failed to develop aecidia of *Puccinia graminis* each season. This is in marked contrast to the findings of Maxwell and Wallace (1926), who stated that the common barberry was widely distributed in a healthy condition over the southern half of Scotland.

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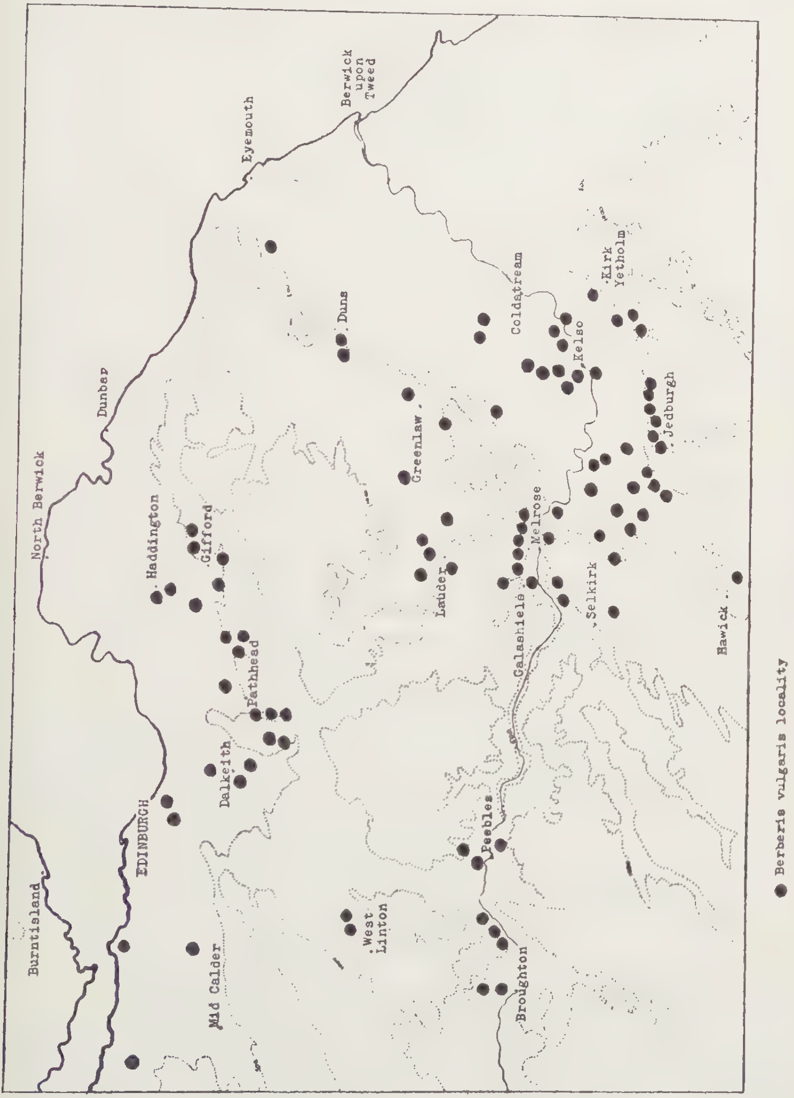
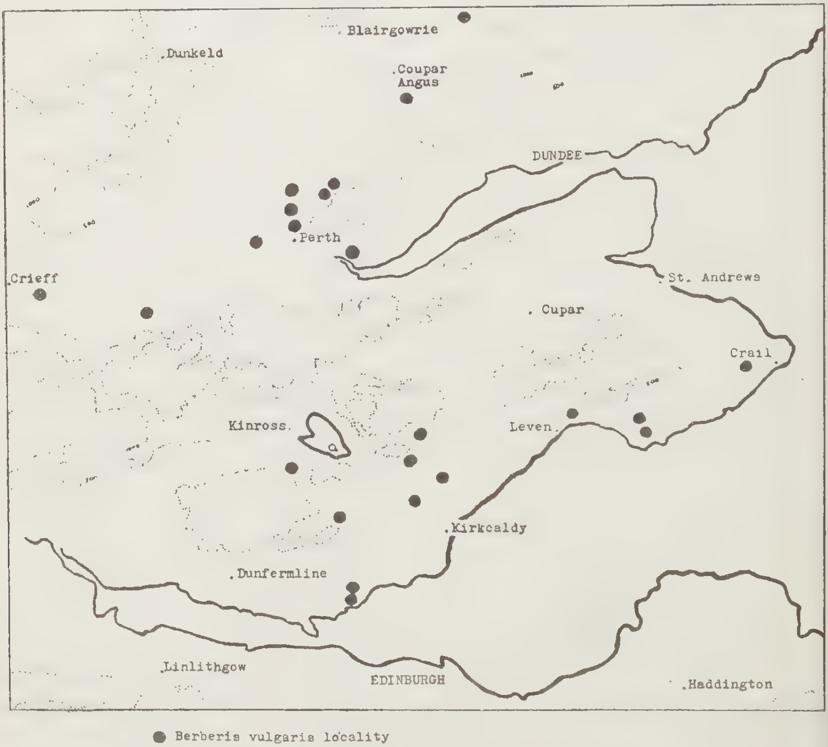


TEXT-FIG. 1.—Distribution of *Berberis vulgaris* in area south of the Forth.

The aecidia occur mainly on the leaves (Pl. IV, fig. 1). Only the young leaves become infected, but the attack may be a severe one. The berries are also frequently infected (Pl. IV, figs. 2 and 3), though the aecidia on them never take on the typical pitted form but resemble little tubular horns. Tubular aecidia and not the pitted aecidia of natural infection are also produced when barberry leaves are artificially inoculated under greenhouse conditions (Pl. IV, fig. 4). A tubular aecidium is about 2–3 mm. long and 0·2 mm. broad: the cells making up the wall are roughly cylindrical and 13 to 18 μ long and 13 μ wide. The aecidia, which were first observed by Smith (1884), remain closed for many weeks. From July onwards the barberry produces new growth. The young stems are often quite severely infected and may become distorted. Aecidia sometimes develop at the junction of stem and thorns, and the resulting swelling completely merges these organs at this point.



Text-fig. 2.—Distribution of *Berberis vulgaris* in area north of the Forth.

Some cultivated species of barberries are known to be susceptible to *P. graminis*, but no infected cultivated species were found in the present investigation.

(*b*) On *Mahonia*

In March 1949 considerable teleutospore infection was observed on couch grass at Crichton, Midlothian, and it was known that the rust had not spread sufficiently far from barberries in 1948 to infect this grass. Bushes of *Mahonia aquifolium* Nutt. were growing in some quantity near the infected couch grass, and in mid-June aecidia began to appear on the berries of the *Mahonia*. By 12th July the adjacent couch stems were bearing uredosori. Berries bearing aecidia were taken back to the greenhouse, and the aecidiospores were inoculated to barley seedlings. Within ten days uredosori were present on the inoculated leaves.

Wilson (1934) notes that Berkeley and Broom and also Stevenson recorded aecidia of *Puccinia graminis* on *Mahonia aquifolium*. They found the aecidia on the leaves, but did not record them on the berries.

A SPECIES OF TUBERCULINA PARASITIC ON PUCCINIA GRAMINIS.

Rusted barberry bushes at Pathhead, Midlothian, on 22nd July 1948, showed many aecidia parasitised by a species of *Tuberculina*, probably *T. persicina*. The parasite was seen again towards the end of July 1949 at Crichton, and at Easthouses, Midlothian. On both occasions it arrested further spread of spores from infected aecidia. Not all the aecidia were infected on any leaf.

There seems to be no previous record of *Tuberculina* occurring naturally on *Puccinia graminis*, but Vladimirskaya (1939) artificially inoculated the spermagonial and aecidial stages of black rust with *Tuberculina persicina* and obtained positive results after an incubation period of eight days. This inhibited further development of the rust. He obtained negative results with inoculations of uredosori.

OCCURRENCE ON CEREALS AND GRASSES.

Maxwell and Wallace (1926) recorded black rust on the following cereals in south Scotland: *Triticum vulgare*, *Hordeum vulgare*, *Avena sativa*, and *Secale cereale*, and on the grasses *Agropyrum repens*, *Agrostis vulgaris*, *Bromus sterilis*, and *Dactylis glomerata*. Dennis and Foister (1942), referring largely to another list (Wilson 1934), included also *Aira caespitosa*, *Alopecurus pratensis*, *Arrhenatherum avenaceum*, *Briza media*, *Festuca pratensis*, and *Lolium spp.*

Hosts.

During the five years under observation, *Puccinia graminis* was found on four cereals and fourteen genera of grasses. A list of these hosts with notes on the occurrence of the rust is given below. The rust is usually found on the leaf-sheaths and flowering stems. In *Agrostis spp.* the leaf blades usually become infected later in the season; this is rare with other grasses.

Avena sativa L. (oats). The cereal most commonly infected. Severe in Roxburghshire, rare in the Lothians and counties north of the Forth. In 1948 and 1949 field experiments on the effect of the rust on oats were carried out in the Melrose area. Fourteen common varieties were grown near barberries. All the varieties were about equally susceptible to the rust, and infection caused reductions in yield and quality of grain and straw.

Hordeum vulgare L. (barley). Occasional and slight on crops growing near barberry bushes.

Secale cereale L. (rye). Rarely seen on the few scattered crops in the area. Occasional in the Ladybank area of Fife where rye is more commonly grown.

Triticum vulgare Vill. (wheat). Infection is rare in south-east Scotland. Seen only a few times, mainly in the Border counties and there slight. Severe on one field in west Berwickshire in August 1947.

Agropyrum repens Beauv. (couch grass). The commonest grass host. Couch grass growing near infected barberry bushes will always be found bearing uredosori or teleutosori according to the time of year. The first uredosori develop on the upper leaf-sheaths just below the auricles of the leaf-blades. Infection generally becomes severe on the leaf-sheaths, flowering stems and inflorescences. The grass is usually the first to become infected each year.

Agrostis canina L. and *A. vulgaris* With. (bent grasses). Frequently infected.

Alopecurus pratensis L. (meadow foxtail). Seen on this host about half a dozen times mainly in Roxburghshire. Occurs rather late in the season and rarely severely.

Anthoxanthum odoratum L. (sweet vernal grass). Extremely rare and only seen in three places in 1949—Midlothian, Peeblesshire and Roxburghshire. Infected plants at each locality were growing in boggy ground and were unusually green for the time of year (October). This grass is normally the first to flower and is usually in a rather senescent condition by the time uredospores are spreading. It thus usually escapes infection. Uredosori and teleutosori are usually present near ground level, but one flowering stem was found with sori near the inflorescence.

Arrhenatherum avenaceum Beauv. (tall or false oat grass). Frequently infected, particularly in the Border counties, and infection appearing some weeks later than on couch grass.

Avena fatua L. (wild oat). The plant is occasionally found near barberry bushes and then may be infected.

Bromus asper Murr. (wood brome grass). This grass is rarely seen in the neighbourhood of barberries. Near Humbie, East Lothian, it grows near a rather large barberry and becomes slightly infected each season.

Bromus sterilis L. (barren brome grass). Slight infection has been observed on this early developing grass in several localities in the Lothians.

Cynosurus cristatus L. (crested dog's tail). This grass becomes infected in a few localities in the Borders fairly late in the season. The sori occur only on the internodes near ground level, and only a few of the plants in any one locality are infected.

Dactylis glomerata L. (cocksfoot). In the Border counties the flowering stems frequently bear teleutosori.

Festuca rubra L. (red fescue). Slight infection seen in July 1949 in a few scattered localities.

Hordeum murinum L. (wall barley). Occasional in Midlothian in the vicinity of barberries.

Phleum pratense L. (timothy). A careful search for black rust was made wherever this grass grows near a source of infection, but only once (November 1946) was it found bearing teleutosori on a few flowering stems. The stems were collected, kept outside over winter, and the following spring the rust from them was inoculated on to young barberry leaves in the greenhouse, with positive results. The stem rust on timothy is often referred to as *Puccinia phleipratensis* Erikss. and Henn. It is indistinguishable from *P. graminis* but is said not to infect barberry.

Poa pratensis L. and *P. trivialis* L. (meadow grasses). In July 1948 teleutosori were found on *Poa trivialis* at two centres in Roxburghshire. This appears to be the first record of *Puccinia* *graminis* on *Poa* in Great Britain. Since then the grass has been found to be infected in several other localities. *Poa pratensis* is also occasionally affected. The infection is often severe.

Trisetum flavescens Beauv. (golden oat grass). This grass is not often found near barberry bushes, but there are some plants growing beneath bushes in the Melrose area and they are usually infected.

A few of the other common grass genera, e.g. *Aira*, *Brachypodium*, *Holcus* and *Lolium*, are frequently found growing near infected barberries, but no infection has been seen on them. Dennis and Foister (1942) recorded uredosori of black rust on *Briza media* in a remote corner of Perthshire, but that area was not visited during the present investigation.

SEASONAL DEVELOPMENT, 1945–1949.

Detailed observations began in September 1946, and the general progress of the disease in south-east Scotland for the five-year period from 1945 until 1949 is briefly given below.

1945: By August, black rust was fairly widespread and often severe, particularly on oat crops in the Border counties. The worst attacks were adjacent to or within a few hundred yards of barberry bushes.

1946: Aecidia were still present on 11th September, and were last seen on 16th October, in Fife. There was little spread of infection from the barberry this year.

1947: On 3rd April barberry buds began to show green tips in Midlothian. The first spermagonia appeared on these bushes on 15th May, and by the end of May aecidiospores were being liberated. In rather marked contrast to the previous year, aecidia were not seen after the end of August. Thus the teleutospores germinated later than usual (*cf.* dates of appearance of aecidia in 1948 and 1949) and apparently germinated in a comparatively short time, for they had finished germinating by mid-August.

The first uredosori were found on 16th June and were generally present until about the end of July, teleutospores appearing rather early. In autumn, infection was severe on all hosts, even several miles from known barberry bushes. Conditions were therefore apparently ideal for the development and spread of the rust.

1948: On 19th March the barberry buds were just showing red tips and by 12th April were rapidly unfolding. The first spermagonia were seen four days later. Aecidia were present on 8th May, liberating spores about a week later, and were observed until the end of September.

The first uredosori were found on 11th June, about four to five weeks after the appearance of aecidiospores compared with three weeks in 1947. Uredospores were present until mid-November. Teleutospores were not present in any quantity until mid-August. Infection spread only a short distance from barberries this year.

1949: Judged by the appearance of the spermagonia, the teleutospores germinated very sporadically in the spring of this year. A few spermagonia were seen at one place in Fife on 25th April, but in many other localities spermagonia were still absent a fortnight later. General infection did not occur until 1st June, but subsequently many bushes became severely infected with aecidia covering almost the entire leaf-surface. Aecidiospores were not present after August.

As might be expected, the appearance of the uredosori was just as sporadic: they were seen first on 14th June but did not become general until the end of that month.

Teleutosori made their appearance rather early. Some were present on oats in mid-July, in an area where uredosori did not appear until late June. The drought which prevailed throughout almost the whole season undoubtedly made conditions unfavourable for uredospore development. On some infected grasses, particularly on shallow soil, very few uredospores were produced.

During October scattered infection was observed on volunteer cereals in root crops, and on couch and cereals growing on middens, often a mile or so away from known barberries. Conditions were apparently not favourable for the spread of the disease until late in the season.

As will be seen, black rust was widespread and severe in 1945 and rather more so in 1947. In 1946 and 1948 the disease was restricted to vegetation near barberries. 1949 was rather an intermediate year; the disease certainly spread from the barberries, but too late in the season to affect the cereal crops.

It has been shown that weather conditions play a large part in determining the intensity of rust attack each season. The possible relationship between the rust development and weather conditions in each season under review was investigated. For this purpose the monthly weather reports from seven meteorological stations in south-east Scotland were examined. A detailed investigation of the results showed that, in years of widespread black rust, there was a distinct tendency for the temperatures during the months of April, May and June to be above average with plentiful and frequent rainfall. The months of July, August and September were warm or very warm, with only moderate amounts of rainfall.

OVERWINTERING.

There are more than sufficient barberries in the south-east of Scotland to account for all the black rust which appears each season. Nevertheless, the possibility of overwintering of the rust without the intervention of the barberry must be considered, in order to be able to judge whether the disease could reappear each season if the barberries (and *Mahonia*) were destroyed.

(a) *By uredospores*

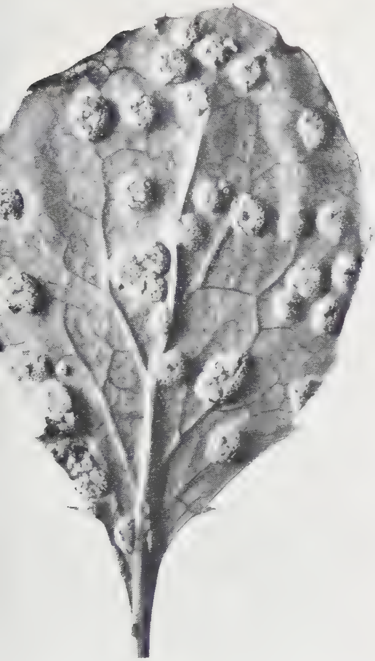
The obvious suggestion is that the rust may survive in the uredospore stage, and special attention was paid to this possibility. A search was made each winter for uredosori, but they were only once found after November, when on 9th December 1947 they were present on volunteer oats growing near a midden. The uredospores were tested for germination on 1 per cent. agar but none germinated.

As already indicated, black rust was widespread in the autumn of 1947. The following winter was very mild, and a special search was made in the spring and summer of 1948 to see if fresh infection appeared on couch and other perennial grasses which were infected in 1947 and which were growing far distant from barberries. Uredospores were never found, however, and no black rust had survived in the uredospore stage in south-east Scotland.

(b) *By perennial mycelium*

It was suggested that the rust might overwinter as internal mycelium in grass hosts. To investigate this point, severely infected clumps of couch and bent grasses were potted in the late summer of 1947. The pots were kept in an unheated greenhouse during the following winter and spring. Fresh uredosori of black rust did not reappear although both sets of plants were flourishing.

These observations therefore tend to confirm the statement made by Maxwell and Wallace (1926) that there is no evidence that the disease is carried over the winter by means of uredospores, and the destruction of barberries will almost certainly result in the disappearance of the disease.



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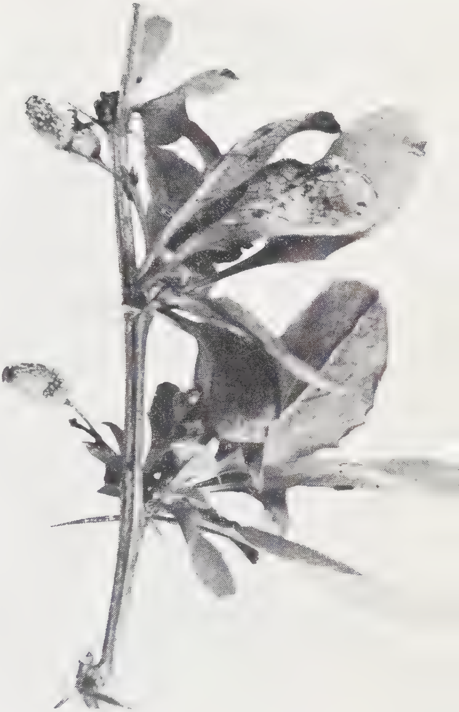

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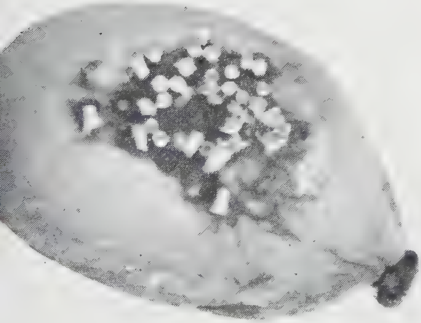

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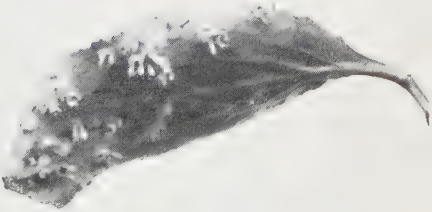

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Fig. 1.—Natural aecidial infection on barberry leaf.

Fig. 2.—Portion of barberry twig with two berries bearing aecidia.

Fig. 3.—An enlarged berry with tubular aecidia (natural infection).

Fig. 4.—Artificially infected barberry leaf with tubular aecidia.

SUMMARY.

In 1945 *Puccinia graminis* was severe in south-east Scotland and the disease was investigated in that area. *Berberis vulgaris* was frequently found, particularly in the Border counties, and in most years the young stems and leaves were well covered with aecidia. At two places in Midlothian, aecidia were parasitised by a species of *Tuberculina*, probably *T. persicina*, and liberation of aecidiospores ceased. The berries of *Mahonia aquifolium* can also function as an alternate host.

Black rust has been found on oats, wheat, barley, rye and fourteen genera of wild grasses. Infection on oats caused reduction in yield of grain and in value of the straw. *Agropyrum repens* is always infected when near barberry.

The development and spread of the rust was observed during the years 1945 to 1949. It was widespread and severe in 1945 and 1947. In 1946 and 1948 the disease did not spread far from the barberries. In 1949 the rust appeared late and only became widespread late in the season.

There is no evidence that the rust can overwinter in any way other than by teleutospores.

ACKNOWLEDGMENTS.

The writer gratefully acknowledges the help and interest of Dr. Malcolm Wilson under whose supervision the work was carried out; the facilities provided by Mr. R. G. Heddle; the assistance with photographs given by members of the staff of the Plant Pathology Station, East Craigs, Edinburgh, and the guidance of Mr. W. C. Moore in the preparation of this paper.

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CONTRIBUTION TOWARDS A FUNGUS FLORA OF THE SMALL ISLES OF INVERNESS.

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(Read by title, 21st February 1952.)

Thanks largely to the labours of Professor Heslop Harrison and his colleagues, the Small Isles parish of Inverness-shire is now probably floristically the best known part of the West Highlands. Though the phanerogams and vascular cryptogams have been thoroughly collected and there is some information regarding the bryophyte and lichen floras, the fungi have hitherto been ignored. The following list of species obtained during a stay of two and a half weeks on Rhum and Eigg in July 1951 is offered as a first step towards a knowledge of the fungus flora. Within a small area like the British Isles the distribution of fungi is likely to be fairly uniform, and it is probable that most of the species in this list could be obtained by a collector of average diligence in any rural parish of the three kingdoms. The number of agaric genera and species would certainly be greatly extended if a collecting trip were made to the islands in September or October. Nevertheless, some interesting features are already apparent, notably the occurrence of woodland agarics like *Psalliota langei* Möller on sea cliffs far from trees, and the development of sub-alpine species like *Omphalia flava* (Cke.) Möller at about the same low altitude as *Mycena filopes* (Bull.) Fr. around the Sgurr of Eigg. Native woodland is almost absent from these islands except for the dense scrub of *Corylus* that clings to the cliffs of Eigg, but it seems likely that most of the agarics listed, which would be regarded as woodland species in the south of England, were able to subsist on the islands prior to the small amount of planting which has been done during the last hundred years. Of agarics, probably only mycorrhizal fungi like *Boletus elegans* (Schum.) Fr. and *B. luteus* (L.) Fr. are to be classed as aliens introduced with, or dependent on, the imported trees. These and other species in the same category are enclosed in brackets in the list.

The number of rusts collected is surprisingly small. Reference to the published flora of the islands shows that the potential hosts of about a hundred and fifty species of British rusts occur on Rhum and Eigg. Of these only twenty-six were collected. No doubt many others are present, though some, like *Melampsora lini* Desm., were specifically sought for in vain. The isles swarm with Euphrasias, yet *Coleosporium euphrasiae* Wint. was found only after prolonged search and then in very small quantity. Powdery mildews were also ill-developed. It would, however, be unwise to generalise from observations over so short a period. Though true of July 1951, they may be inapplicable to other years or seasons.

In addition to the named species and the usual number of sterile or otherwise inadequate collections, there are two apparently adequately collected species of agarics, an *Inocybe* and a *Cortinarius*, and two of discomycetes for which names have not yet been found. The conventional procedure with collections of this kind not matched amongst published descriptions is to describe them as "new" species. This I am unwilling to do for two reasons. First, the agarics belong to difficult and critical genera, and the *Cortinarius* to a subgenus which has never been adequately worked out in any part of the globe; hence the interpretation of many of its older species remains uncertain. The discomycetes are very minute inoperculatae. A large number of these were briefly described in vaguely defined genera during the last century in Europe, and until as many as possible of the types have been located and re-examined by specialists it will be rash to regard any British inoperculate discomycete as a new species. Secondly, description of new species from somewhat isolated islands may, to some readers, imply endemism. For this there is no evidence in the present state of knowledge of the British fungus flora. On the other hand, there can be little progress towards a full knowledge of that flora if all unidentified collections are passed over in silence. As a compromise, therefore, I propose to describe and figure the two unidentified discomycetes in the hope that other collectors will recognise them again until sufficient material accumulates for their status to be elucidated. The collections of *Phialia incertella* Rehm, *Chitonospora ammophilae* Bomm. Rouss. & Sacc., and of *Pleospora multiseptata* Starback represent additions to the known British flora. It has therefore seemed desirable to figure them also. A detailed description of the Rhum material ascribed to the first-named species will be found at the end of this paper.

An asterisk (*) indicates species for which no earlier Scottish record has been traced, but it must not be inferred that they are rare or even local in distribution. It is gratifying to be able to supply a verified record of *Peronospora oerteliana* Kühn from the north-west. Previous Scottish records of this species are believed to have been based on collections of *Ovularia primulana* Thüm.

BASIDIOMYCETES.

AGARICALES.

*LACCARIA PROXIMA Boud. Wet deciduous wood, Papadil
MYCENA ALCALINA Fr. On *Pinus* stump, Kildonan wood, Eigg
M. AMMONIACA Fr. Manse wood, Eigg
*M. CHLORANTHA Fr. Manse wood, Eigg
M. FILOPES (Bull.) Fr. sensu Lange Under *Pinus*, Kinloch; In *Rhacomitrium* amongst rocks, Loch Beinn Tighe, Eigg
M. GALOPUS (Pers.) Fr. Under *Pinus*, Kinloch
M. HAEMATOPUS (Pers.) Fr. Papadil; Kinloch; Manse wood, Eigg
M. HIEMALIS (Osbeck) Fr. In gorge beside path to Barkeval
M. RUBROMARGINATA Fr. sensu Pearson (= M. CAPILLARIPES Peck). Kildonan wood, Eigg
M. SANGUINOLENTA (A. & S.) Fr. Under *Salix* and *Pinus*, Kinloch; Manse wood, Eigg
M. TENERRIMA Berk. On *Corylus*, Galmisdale, Eigg
M. VITILIS Fr. sensu Lange Under *Pinus*, Kinloch
COLLYBIA DRYOPHILA (Bull.) Fr. Under *Pinus*, Kinloch
C. ESCULENTA (Wulf.) Fr. On coniferous debris, Kinloch
MARASMIUS ANDROSACEUS (L.) Fr. Under *Pinus* with *Calluna*, Kinloch
M. ROTULA (Scop.) Fr. Under *Pinus* and on bark at base of living *Acer pseudoplatanus* trunk, Kinloch
OMPHALIA FIBULA (Bull.) Fr. Plantations, Kinloch
O. FLAVA (Cke.) Möller Vertical rocks of the Sgurr, Eigg
O. UMBELLIFERA (L.) Fr. Moors near Rudha na Roinne
PLEUROTUS OSTREATUS (Jacq.) Fr. Logs, Papadil
HYGROPHORUS CHLOROPHANUS Fr. Kinloch
H. MINIATUS Fr. Path to Barkeval; Kilmory
*H. RICKENII Maire (= H. CONSTANS Lange). Kinloch; Galmisdale, Eigg
LACTARIUS DELICIOSUS (L.) Fr. Under *Pinus* Kinloch
*L. LACUNARUM (Romagn.) Lange Galmisdale, Eigg
L. LILACINUS (Lasch) Fr. Kinloch
L. RUFUS (Scop.) Fr. Kinloch
L. SUBDULCIS (Pers.) Fr. Kinloch
*RUSSULA CESSANS Pearson Kinloch
R. CLAROFLAVA Grove. South side of Loch Scresort
R. CYANOXANTHA (Schaeff.) Fr. South side of Loch Scresort
R. DELICA Fr. Manse wood, Eigg
R. FRAGILIS Fr. Under *Pinus*, south shore of Loch Scresort
R. HETEROPHYLLA Fr. South shore of Loch Scresort
R. SCOTICA Pearson Under *Pinus*, Kinloch
PLUTEUS CERVINUS (Schaeff.) Fr. On *Betula*, Kinloch
ENTOLOMA AMEIDES Berk. & Br. Pastures, Harris; Kilmory
E. JUBATUM Fr. Moors, Kilmory; Dibidil; Kinloch
*RHODOPHYLLUS RADIATUS Lange Papadil
*LEPTONIA PLACIDA Fr. Pasture, Harris
L. SERICELLA (Fr.) Quél. Kinloch
NOLANEA STAUROSPORA Bres. Moor, Fionn chro. Under *Picea* and *Betula*, Kinloch

*Eccilia cancrina Fr. Pasture, Harris
Pholiota erebia Fr. Papadil
P. flammans Fr. Under *Pinus*, Kinloch
P. mutabilis (Schaeff.) Fr. On *Salix*, Kinloch
P. praecox var. paludosa Lange Amongst *Juncus*, Galmisdale, Eigg
Inocybe cincinnata Fr. Under *Larix*, Manse wood, Eigg
I. fastigiata (Schaeff.) Fr. Under *Fagus*, Manse wood, Eigg
I. flocculosa Berk. Shrubbery, Kinloch; Manse wood, Eigg
*I. lacera Fr. f. subsquarrosa Möller Moors, Kilmory
*I. lanuginella Schroet. Under *Pinus*, Kinloch
I. obscura (Pers.) Fr. sensu Lange Kinloch
I. pyriodora (Pers.) Fr. Under *Betula*, Kinloch
*I. umbrina Bres. Under *Betula* and *Sorbus*, Kinloch
*I. xanthomelas Kühner & Boursier Kinloch
Naucoria myosotis Fr. Galmisdale, Eigg
N. scolecina Fr. f. gracillima Lange Kinloch
*N. vervacti Fr. sensu Lange. Laig dunes, Eigg
*Galera coprophila Kühner On faeces of *Bos*, Harris
G. hypnorum (Batsch) Fr. Kinloch; Eigg
G. rubiginosa (Pers.) Fr. Moors, Fionn chro
*G. sahleri Quél. sensu Favre On peat, Eigg
G. tenera (Schaeff.) Fr. f. semiglobata Kühner Fionn chro
*G. tibiicystis Atkinson In *Sphagnum*, Kinloch
Tubaria furfuracea (Pers.) Gill. Kinloch; Papadil; Eigg
T. paludosa (Fr.) Karst. In *Sphagnum*, Kinloch; Galmisdale, Eigg
Bolbitius vitellinus (Pers.) Fr. Kinloch
Crepidotus mollis (Schaeff.) Fr. On *Rhododendron*, Kinloch
Stropharia semiglobata (Batsch.) Fr. Rhum; Eigg
Hypholoma candolleanum Fr. Kinloch
H. fasciculare (Huds.) Fr. Kinloch; Eigg
Psilocybe coprophila (Bull.) Fr. On faeces of *Bos*, Harris; Eigg
P. foenisecii (Pers.) Fr. Kinloch
*P. uda (Pers.) Fr. sensu Lange In *Sphagnum*, Fionn chro
Psathyrella obtusata (Fr.) A. H. Smith sensu Lange Amongst *Ammophila*, Laig, Eigg
Panaeolus campanulatus (L.) Fr. Kinloch
P. campanulatus (L.) Fr. var sphinctrinus (Fr.) Bres. Kinloch; Galmisdale, Eigg
Anellaria semi-ovata (Sow.) Pearson & Dennis Rhum; Eigg
Psalliota campestris (L.) Fr. Pasture, Harris
P. langei Möller (=P. haemorroidaria sensu Lange). Under *Pinus*, Kinloch; on open sea cliffs west of Kilmory
*P. porphyria Möller On wet moors, Kinloch
Coprinus micaceus (Bull.) Fr. Papadil; Kinloch; Manse wood, Eigg
*C. patouillardii Quél. On faeces of *Equus*, Harris
C. plicatilis (Curt.) Fr. North coast of Eigg
(Boletus elegans (Schum.) Fr. Under *Pinus*, Kinloch)
(B. luteus (L.) Fr. Under *Pinus*, Kinloch; Eigg)
*B. carpini (R. Schulz) Pearson Under *Corylus*, Kildonan, Eigg
B. chrysenteron (Bull.) Fr. Kinloch; Eigg

Aphyllophorales.

Polyporus caesius (Schrad.) Fr. South shore of Loch Scresort
P. radiatus (Sow.) Fr. On *Alnus*, Papadil
P. varius Fr. On *Salix*, Kinloch

Poria mucida (Pers.) Fr. On *Ulex*, Papadil
Polystictus versicolor (L.) Fr. On *Betula*, Kinloch; Papadil
(Fomes annosus Fr. On *Pinus*, Kinloch)
Trametes mollis (Sommerf.) Fr. Kinloch; Papadil
Stereum hirsutum (Willd.) Fr. Kinloch
Hymenochaete corrugata (Fr.) Lév. On *Corylus*, Galmisdale, Eigg
*Grandinia brinkmanni (Bres.) Bourd. & Galz. On *Salix*, Kinloch
Tomentella sp. Kinloch
Peniophora cinerea (Fr.) Cke. On *Fraxinus*, Kinloch; on *Tilia*, Papadil
P. glebulosa (Fr.) Bres. On *Pinus*, Kinloch
P. hydnoides Cke. & Massee On *Betula*, Kinloch; Papadil
P. maculaeformis (Fr.) Bourd. & Galz. On *Salix*, Kinloch
Corticium polygonium (Pers.) Fr. On *Populus*, Kildonan cliffs, Eigg
C. sambuci (Pers.) Fr. On *Sambucus*, Eigg
*C. sphaerosporus R. Maire Kinloch
Cyphella albo-violascens (Alb. & Schw.) Karst. On *Euonymus* and *Acer*, Kinloch
C. villosa (Pers.) Karst. On *Rumex*, Kinloch; on *Senecio*, Kildonan, Eigg
Clavaria cinerea (Bull.) Fr. Kinloch
C. cristata (Holmsk.) Fr. Manse wood, Eigg
Pistillaria micans (Pers.) Fr. On *Rubus*, Galmisdale, Eigg

Tremellales.

Tremella mesenterica (Retz.) Fr. On logs, Papadil
Exidia nucleata (Schw.) Burt Papadil; Kildonan, Eigg
E. saccharina Fr. On *Pinus*, Kildonan, Eigg
*Sebacina fugacissima Bourd. & Galz. On *Hedera*, Kinloch

Calocerales.

Calocera cornea (Batsch) Fr. Papadil
Dacryomyces deliquescens (Bull.) Duby. Kinloch

Gasteromycetales.

Calvatia caelata (Bull.) Morg. Sand dunes, Kilmory, mostly consumed by *Cervus* or *Bos*
Lycoperdon perlatum Pers. Galmisdale, Eigg

Ustilaginales.

Ustilago violacea (Pers.) Fuck. On *Lychnis flos-cuculi*, Kinloch
U. avenae (Pers.) Rostr. On *Avena sativa*, Kildonan, Eigg
Entyloma microsporum (Ung.) Schroet. On *Ranunculus acris*, Kinloch

Uredinales.

Coleosporium euphrasiae Wint. II on *Euphrasia*, Kildonan, Eigg
Melampsora hypericorum Wint. II on *Hypericum androsaemum*, Galmisdale, Eigg
Milesina dieteliana P. Magn. II on *Polypodium vulgare*, Kinloch
Phragmidium mucronatum (Pers.) Schlecht. I on *Rosa spinosissima*, Kildonan, Eigg; II on *Rosa* sp., Laig, Eigg
P. violaceum Wint. II on *Rubus 'fruticosus'*, Kildonan cliffs, Eigg
Puccinia acetosae Körn. II on *Rumex acetosa*, Kildonan, Eigg
P. angelicae Fuck. II on *Angelica silvestris*, Laig, Eigg
P. brunellarum-moliniae Cruchet OI on *Prunella vulgaris*, Galmisdale, Eigg

P. CARICIS Reb. I on *Urtica dioica*, Kinloch
P. CENTAUREAE DC. II on *Centaurea nigra*, Kinloch
P. CHRYSOSPLENII Grev. III on *Chrysosplenium oppositifolium*, Manse wood, Eigg
P. CIRSII-LANCEOLATI Schroet. II on *Cnicus lanceolatus*, Harris; Cleadale, Eigg
P. EXPANSA Link III on *Senecio jacobaea*, Kildonan, Eigg; Laig, Eigg
P. HIERACII Mart. II on *Hieracium pilosella*, Galmisdale, Eigg; on *Hieracium* sp., Kilmory
P. HOLCINA Erikss. II on *Holcus lanatus*, Kinloch
P. OBTEGENS Tul. II on *Cnicus arvensis*, Galmisdale, Eigg
P. PALUDOSA Plowr. I on *Pedicularis palustris*, path to Barkeval
P. PRIMULAE Duby II on *Primula vulgaris*, Papadil
P. SONCHI Rob. II on *Sonchus oleraceus*, Kildonan, Eigg
P. TARAXACI Plowr. II and III on *Taraxacum officinale*, Kilmory
P. VIOLAE DC. I and II on *Viola* sp., Kinloch
TRIPHRAGMIUM ULMARIAE Wint. II on *Filipendula ulmaria*, Laig, Eigg
UREDO ANTHOXANTHINA Bub. II on *Anthoxanthum odoratum*, Kinloch
UROMYCES ALCHEMILLAE Pers. II on *Alchemilla vulgaris*, Laig, Eigg
U. FLECTENS Lagh. II on *Trifolium repens*, Laig, Eigg
U. POAE Raben. II and III on *Poa trivialis*, Papadil
U. VALERIANAE Fuck. I and II on *Valeriana officinalis*, Kildonan, Eigg

ASCOMYCETES.

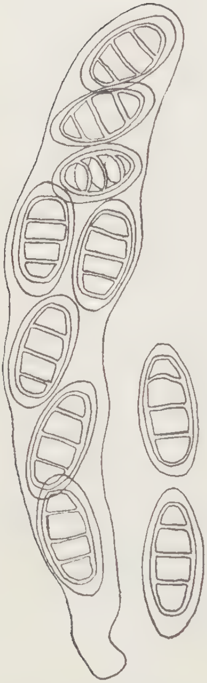
PERISPORIALES.

ERYSIPHE GRAMINIS DC. On *Dactylis*, Galmisdale, Eigg
SPHAEROTHECA HUMULI (DC) Burrill Conidial on *Potentilla reptans*, Rhum
*CAPNODIUM FOOTII Berk & Desm. On *Ligustrum*, Kinloch

SPHAERIALES.

*CHITONOSPORA AMMOPHILAE Bomm. Rouss. & Sacc. On *Ammophila*, Kilmory
CLYPEOSPHAERA NOTARISII Fuck. On *Rubus* '*fruticosus*', Kinloch
(*GNOMONIA INCLINATA (Desm.) Auersw. On *Acer* petioles, Kinloch)
*DIDYMELLA GLACIALIS Rehm On *Poa chaixii*, Kinloch
*D. PACHYSPORA Bomm. Rouss. & Sacc. On *Festuca*, Harris
HYPOXYLON FUSCUM (Fr.) Fr. On *Corylus*, Galmisdale, Eigg
H. RUBIGINOSUM (Fr.) Fr. Papadil
*LEPTOSPHAERIA CULMORUM Auersw. On *Agrostis*, Kinloch
L. DERASA (Berk. & Br.) Auersw. On *Senecio*, Cleadale, Eigg
*L. DUMETORUM Niessl On *Urtica*, Kinloch
(*MYCOSPHAERELLA LATEBROSA (Cke.) Schroet. On *Acer* Kinloch)
*M. MINOR (Karst.) Johans. On *Sedum anglicum*, Dibidil
*M. RECUTITA (Fr.) Johans. On *Koeleria*, Harris
M. RUMICIS (Desm.) Grove f. CAULICOLA Grove On *Rumex*, Kinloch
*M. TASSIANA (De Not.) Johans. On *Molinia*, Kinloch
PHARCIDIA EPICYMATIA (Wallr.) Wint. On a sterile lichen thallus, Kinloch
(PHYSALOSPORA GREGARIA Sacc. f. FOLIORUM Sacc. On *Taxus*, Kinloch)
*P. ILICIS (Schleich.) Sacc. On *Ilex*, Kinloch
PLEOSPORA HERBARUM (Pers.) Rabh. On *Anthyllis*, *Armeria*, *Carex panicea*, *Cochlearia* and *Koeleria*, Harris; on *Arenaria norvegica*, Rhum; on *Cerastium*, Kilmory; on *Festuca rubra*, Galmisdale, Eigg
* P. MULTISEPTATA Starback Kilmory (fig. 2).
ROSELLINIA MAMMIFORMIS (Fr.) Ces. & De Not. On *Hedera*, Kinloch

SPHAERELLA STELLARINEARUM Karst. On *Cerastium*, Papadil
XYLARIA HYPOXYLON (Fr.) Grev. Manse wood, Eigg
LOPHIDIUM COMPRESSUM (Pers. ex Fr.) Sacc. On *Salix*, Kinloch



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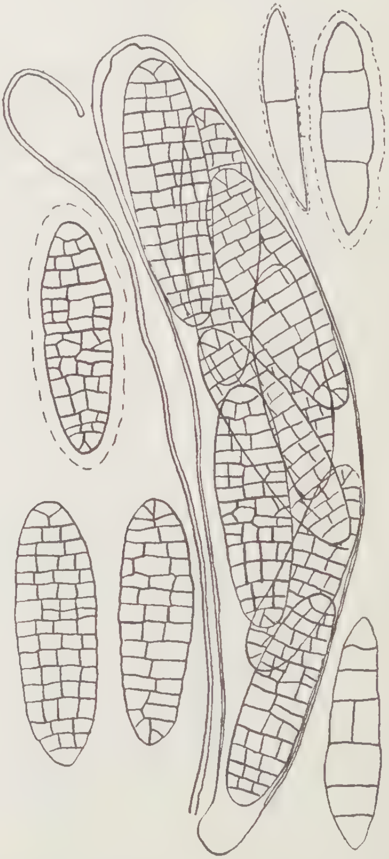

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FIG. 1.—Ascospores of *Chitonospora ammophilae* Bomm. Rouss. & Sacc. (×660.)

FIG. 2.—*Pleospora multispeptata* Starback Centre: Ascus and pseudoparaphysis. Left: Mature yellow-brown ascospores, one showing its hyaline gelatinous coat. Right: 3 stages in spore development from unripe asci. (All ×660.)

HYPOCREALES.

DIALONECTRIA GALLIGENA (Bres.) Petch On *Malus*, Kinloch
D. SANGUINEA (Bolt. ex Fr.) Cke. On *Acer pseudoplatanus*, Papadil
CLAVICEPS PURPUREA (Fr.) Tul. Sclerotia on *Anthoxanthum*, Kinloch

DOTHIDEALES.

DOTHIDELLA TRIFOLII Bayliss Elliott & Stansf. On *Trifolium repens*, Kinloch
RHOPOGRAPHUS FILICINUS (Fr.) Fuck. On *Pteridium* Kinloch

HYSTERIALES.

*AULOGRAPHUM FILICINUM Lib. On fern stems, south side of Beinn Tighe, Eigg

FARLOWIELLA CARMICHAELIANA (Berk.) Sacc. On *Pinus* and *Betula* Kinloch

HYPODERMA COMMUNE (Fr.) Duby On *Sedum rhodiola*, Fionn chro

H. VIRGULTORUM DC. ex Sacc. On *Rubus idaeus*, Kinloch

LOPHODERMIUM GRAMINEUM (Fr.) Chev. On *Ammophila*, Kilmory

(L. PINASTRI (Schrad. ex Fr.) Chev. On *Pinus*, Kinloch)

DISCOMYCETALES.

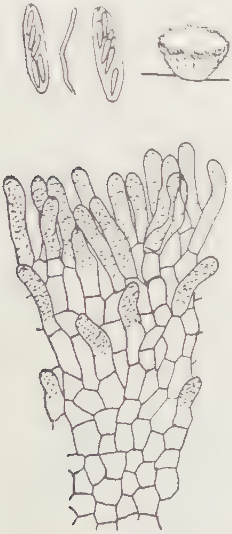
COPROBIA GRANULATA (Bull. ex Fr.) Boud. On faeces, Kinloch

LASIOBOLUS EQUINUS [Mull.] Karst. On faeces of *Cervus*, Barkeval

MACROPODIA MACROPUS (Pers. ex Fr.) Fuck. Manse wood, Eigg

TAPHRINA AMENTORUM (Sadeb.) Rostr. On ♀ catkins of *Alnus*, Kinloch; Galmisdale, Eigg

T. POTENTILLAE (Farl.) Johans. On *Potentilla erecta*, moors north of Beinn Tighe, Eigg



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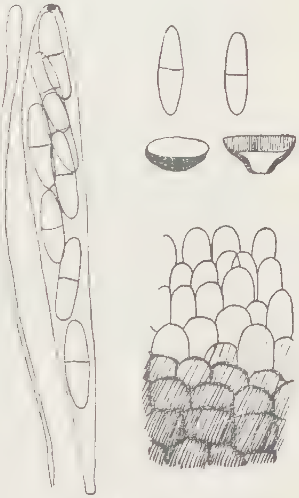

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FIG. 3.—*Dasyscypha* sp. near *fugiens*. Habit sketch. (× 90.) Asci, paraphysis and surface view of excipulum. (× 660.)

FIG. 4.—*Mollisia* sp. on grass. Habit sketch and section. (× 40.) Ascus, paraphysis, spores and marginal portion of excipulum in surface view. (× 660.)

T. TOSQUINETII (Westend.) Tul. On leaves of *Alnus*, Galmisdale, Eigg

BELONIDIUM VEXATUM De Not. On Gramineae, Kinloch

CHLOROSPLENIUM AERUGINOSUM (Oed. ex Fr.) De Not. Kinloch

CORYNE SARCOIDES (Jacq. ex Fr.) Tul. Conidial state, Kinloch

CORYNELLA GLABROVIRENS Boud. Manse wood, Eigg

(DIDYMASCELLA THUJINA (Dur.) Maire. On *Thuja plicata*, Galmisdale, Eigg)

DASYSCYPHA APALA (Berk. & Br.) Dennis On *Juncus*, Kinloch

D. CORTICALIS (Pers. ex. Fr.) Massee On *Populus*, Kildonan, Eigg

D. sp. near D. FUGIENS (Buckn.), Massee On Gramineae, Fionn chro (fig. 3)

*D. NUDIPES (Fuck.) Sacc. f. B. On *Rubus idaeus, Rumex* and *Chamaenerium*, Kinloch
D. PALEARUM (Desm.) Massee On *Ammophila*, Kilmory
*D. PUDICELLA (Quél.) Sacc. On *Festuca*, Fionn chro
D. VIRGINEA (Batsch ex Fr.) Fuck. On *Corylus*, Galmisdale, Eigg
*HELOTIUM CAUDATUM (Karst.) Vel. On *Corylus*, Galmisdale, Eigg
H. EBURNEUM (Desm.) Gill. On Gramineae, Kinloch
HETEROSPHAERIA PATELLA (Tode ex Fr.) Grev. On *Angelica*, Eigg
HYALOSCYPHA LEUCONICA (Cke.) Nannf. On *Pinus*, Kinloch
H. STEVENSONII (Berk. & Br.) Nannf. On *Pinus*, Kinloch

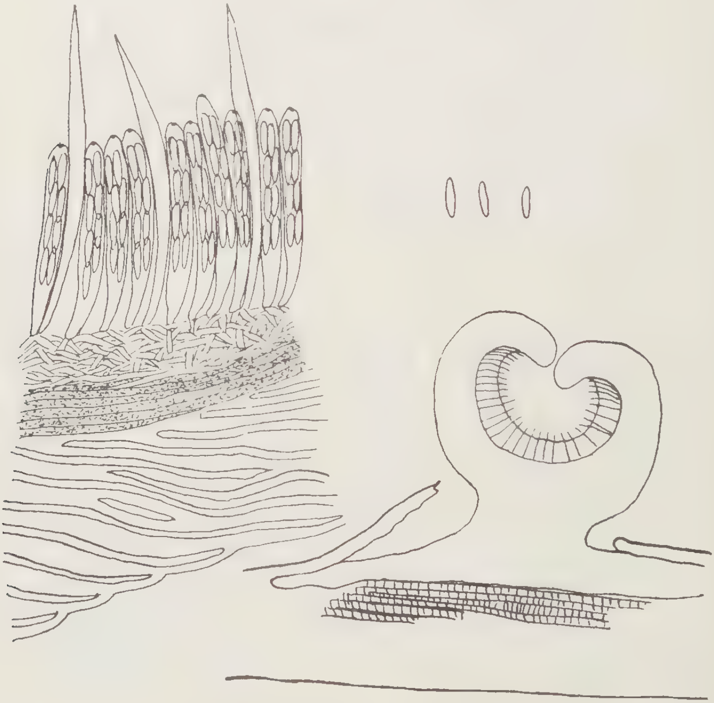

FIG. 5.—*Phailea incertella* Rehm. Details of hymenium and excipulum. (× 660.) Diagrammatic section of apothecium on leaf. (× 90.)

KARSCHIA LIGNYOTA (Fr.) Sacc. On *Ulex*, Papadil
*MICROSCYPHA GRISELLA (Rehm) Syd. On *Pteridium*, Kinloch
MITRULA PALUDOSA Fr. Roadside burn four miles west of Kinloch
MOLLISIA ARENIVAGA (Desm.) Phill. On *Ammophila*, Kilmory
M. CINEREA (Batsch ex Fr.) Karst. Kinloch
*M. CULMINA (Sacc.) Rehm On Gramineae, Kinloch
*M. REVINCTA Karst. On *Rumex* and *Rubus idaeus*, Kinloch
M. VENTOSA Karst. Kinloch
M. sp. On Gramineae (fig. 4), Fionn chro
OMBROPHILA CLAVUS (Alb. & Schw.) Fr. Manse wood, Eigg
PEZICULA RUBI (Lib.) Niessl On *Rubus 'fruticosus'*, Kinloch; Galmisdale, Eigg
PHIALEA INCERTELLA Rehm On *Koeleria*, Harris (fig. 5)

P. PTERIDICOLA (Crouan) Gill. On *Pteridium*, Kinloch
PROPOLIS VERSICOLOR Fr. On *Larix* and *Salix*, Kinloch
PSEUDOPEZIZA CERASTIORUM (Wulf.) Fuck. On *Cerastium*, Papadil
P. RANUNCULI (Wallr.) Fuck. On *Ranunculus acris*, Kinloch
P. TRIFOLII (Biv-Bern.) Fuck. On *Trifolium repens*, Kinloch
PYRENOPEZIZA DIGITALINA (Phill.) Sacc. On *Digitalis*, Kinloch
(P. PETIOLARIS (Alb. & Schw.) Nannf. On *Acer pseudoplatanus*, Kinloch)
P. RUBI (Fr.) Rehm On *Rubus idaeus*, Kinloch
(RHYTISMA ACERINUM (Pers.) Fr. On *Acer pseudoplatanus*, Kinloch)
(R. PUNCTATUM (Pers.) Fr. On *Acer pseudoplatanus*, Kinloch)
STEGIA ILICIS Fr. On *Ilex*, Kinloch
(TRICHOSCYPHELLA CALYCINA (Schum. ex Fr.) Nannf. On *Pinus*, Manse wood, Eigg)
(TROCHILA LAUROCERASI (Desm.) Fr. On *Prunus laurocerasus*, Kinloch)
UNGUICULARIA SCRUPULOSA (Karst.) von Höhn. On *Rubus idaeus*, Kinloch

PHYCOMYCETES.

ACHLYA APICULATA de By. Isolated from water in pool on foreshore, Loch Scresort; seepage on moor between Kinloch and Rudha na Roinne
*A. DUBIA Coker Isolated from water in pool on foreshore, Loch Scresort
*A. MEGASPERMA Humphrey Isolated from water of a pool near the landing, Galmisdale, Eigg
CYSTOPUS CANDIDUS (Pers.) de By. On *Cardamine*, Kildonan, Eigg
PERONOSPORA OERTELIANA Kühn. On *Primula vulgaris*, Papadil
P. TRIFOLIORUM de By. On *Trifolium medium*, Kildonan, Eigg
PLASMOPARA DENSA (Rab.) Schroet. On *Euphrasia*, Kildonan, Eigg
P. NIVEA (Ung.) Schroet. On *Angelica silvestris*, Galmisdale, Eigg
*PYTHIUM PROLIFERUM Petersen Isolated from water of a pool near the landing, Galmisdale, Eigg
SPINELLUS FUSIGER (Fr.) van Tiegh. On *Mycena rubromarginata*, Kildonan wood, Eigg
PROTOMYCES MACROSPORUS Ung. On *Aegopodium*, Kinloch
P. PACHYDERMUS Thüm. On *Taraxacum*, Kinloch

MYXOMYCETES.

ARCYRIA DENUDATA (L.) Wettst. Kinloch
CERATIOMYXA FRUTICULOSA (Müll.) Macbr. Papadil
FULIGO SEPTICA (L.) Gmel. Kinloch
LYCOGALA EPIDENDRUM (L.) Fr. Kinloch

FUNGI IMPERFECTI.

SPHAEROPSIDALES.

ASCOCHYTA GRAMINICOLA Sacc. On *Ammophila*, Kilmory; on *Festuca rubra*, Galmisdale, Eigg
*A. LAPPAE Kab. & Bub. On *Arctium*, Eigg
A. VICIAE Lib. On *Vicia sepium*, Kinloch
CONIOTHYRIUM FUCKELII Sacc. On *Cytisus laburnum*, Kinloch
*CYTOSPORA MICROSTOMA Sacc. On *Prunus spinosa*, Kinloch
DENDROPHOMA PULVIS-PYRIUS Sacc. On *Ligustrum*, Kinloch
DILOPHOSPORA ALOPECURI (Fr.) Fr. On *Holcus lanatus*, Kinloch
*DIPLODIA ULICIS Sacc. & Speg. On *Ulex*, Kinloch
DINEMASPORIUM GRAMINUM Lév. On Gramineae, Kinloch; on *Ammophila*, Kilmory; on *Cynosurus*, Laig, Eigg; apparently this species also on *Orobus sativus*, path to Barkeval

DISCELLA CARBONACEA (Fr.) Berk. & Br. On *Salix*, Kinloch

HENDERSONIA CULMICOLA Sacc. var. MINOR Sacc. On *Festuca vivipara*, Dibidil

H. CULMISEDA Sacc. On *Phragmites*, Kinloch

PHLEOSPORA AEGOPODII (Preuss) Grove On *Aegopodium*, Kinloch

*PHOMA GRAMINELLA Sacc. On *Festuca*, Harris

P. OLERACEA Sacc. On *Cochlearia*, Harris

(P. RHODORAE Cke. On *Rhododendron* leaves, Galmisdale, Eigg)

P. URTICAE Sch. & Sacc. On *Urtica*, Kinloch

PHOMOPSIS PULLA (Sacc.) Trav. On *Hedera*, Kinloch

P. SAROTHAMNI (Sacc.) von Höhn. On *Sarothamnus*, Kinloch

(P. STICTICA (Berk. & Br.) Trav. On *Buxus*, Kinloch)

*PHYLLOSTICTA ALPINA Allesch. var. HELVETICA Jaap On dead and fading leaves of *Arabis petraea*, Barkeval

(*P. CYTISI Desm. On *Cytisus laburnum*, Kinloch)

P. HEDERICOLA Dur. & Mont. On *Hedera*, Kinloch

*RHABDOSPORA HYPOCHAERIDIS Allesch. On *Hypochaeris radicata*, Kinloch

SEPTORIA CONVOLVULI Desm. On *Calystegia sepium*, Kinloch

*SEPTORIA FRAGARIAE Desm. On *Fragaria vesca*, south-west point of Eigg

S. HYDROCOTYLES Desm. On *Hydrocotyle vulgaris*, Papadil

S. OXYSPORA Penz. & Sacc. On *Triodia decumbens*, Guirdil

S. ROSAE Desm. On *Rosa*, Kinloch

S. STELLARIAE Rob. & Desm. On *Stellaria media*, Galmisdale, Eigg

STAGONOSPORA COMPTA (Sacc.) Died. On *Trifolium repens*, Laig, Eigg

MELANCONIALES.

*MYXOSPORIUM BELLULUM (Preuss) Sacc. On die-back of *Alnus*, Kinloch

PROSTHEMIUM BETULINUM Kunze Kinloch

HYPHOMYCETALES.

*ARTICULOSPORA INFLATA Ingold Isolated from water of Allt Slugan Coire Dubh

*A. TETRACLADIA Ingold Isolated from water of Allt Slugan Coire Dubh and from pool near the landing, Galmisdale, Eigg

BOTRYTIS CINEREA Pers. ex Fr. On *Centaurea*, Kinloch; on *Primula*, Kilmory; on *Polygonum persicaria*, on *Rosa* and spreading from fallen petal to attack living leaf of *Rhododendron*, Galmisdale, Eigg

EPICOCCUM PURPURASCENS Ehrenb. ex Wallr. On *Festuca*, Harris

EXOSPORIUM TILIAE Link ex Wallr. On *Tilia*, Papadil

FUSARIUM LATERITIUM Nees ex Fr. On dying twigs of *Euonymus europaeus*, Kinloch

*F. SCIRPI Lamb. & Fautr. var. ACUMINATUM (Ell. & Ev.) Woll. On blighted inflorescences of *Schoenus nigricans*, Harris

FUSICLADIUM DENDRITICUM (Wallr.) Fuck. On *Malus*, Kinloch

GRAPHIUM GROVEI Sacc. On *Pinus*, Kinloch

HELMINTHOSPORIUM APICULATUM Corda On *Salix*, Kinloch

H. VELUTINUM Link ex Fr. Papadil

MASTIGOSPORIUM RUBRICOSUM (Dearn. & Barth.) Nannf. On *Dactylis*, Kinloch

OIDIUM CONSPERSUM Link Kinloch

*OVULARIA DEUSTA (Fuck.) Sacc. On *Lathyrus pratensis*, Kinloch

O. OBLIQUA (Cke.) Oud. On *Rumex*, Eigg

O. SPHAEROIDEA (Sacc.) Sacc. On *Lotus uliginosus*, Kinloch

RAMULARIA ANGELICAE von Höhn. On *Angelica silvestris*, Galmisdale, Eigg

R. CALTHAE (Erikss.) Lindr. On *Caltha palustris*, Kinloch
R. KNAUTIAE (Massal.) Bub. On *Succisa pratensis*, Galmisdale, Eigg
R. LACTEA (Desm.) Sacc. On *Viola*, Kinloch
R. PRATENSIS Sacc. On *Rumex acetosa*, Kildonan, Eigg
R. SENECIONIS (Berk. & Br.) Sacc. On *Senecio jacobaea*, Kildonan, Eigg
R. TARAXACI Karst. On *Taraxacum*, Kinloch
R. VALERIANAE (Speg.) Sacc. On *Valeriana officinalis* Kildonan, Eigg
SPHAERIDIUM CANDIDUM Fuck. On *Pinus*, Kinloch
*TETRACLADIUM SETIGERUM (Grove) Ingold Isolated from water of Allt Slugan Coire Dubh
TETRAPLOA ARISTATA Berk. & Br. On *Agrostis*, Kinloch
TORULA OVALISPORA Berk. On *Tilia*, Papadil
*TRIPOSPORIUM CAMBRENSE Hughes On *Rhododendron*, Kinloch
(VERTICILLIUM BUXI (Link ex Fr.) Auersw. & Fleisch. On *Buxus*, Kinloch)
(VOLUTELLA BUXI (DC. ex Fr.) Berk. & Br. On *Buxus*, Kinloch)

DASYSCYPHA sp.

Apothecia sessile, cup-shaped, white to cream-coloured throughout, disc about 100 μ diameter; excipulum of thin-walled angular textura prismatica, individual cells about 5–12 × 4–5 μ, running out into short cylindrical thin-walled hairs up to 15 × 4 μ, non-septate, with minutely granulate walls; asci sessile, 16–17 × 4–5 μ, cylindric-fusiform, 8-spored, the minute pore blue in Melzer's reagent, spores clavate, tapering below, 5–6 × 1–1·5 μ, paraphyses slender, filiform, obtuse, 1 μ thick.

On dead leaf of ? *Festuca rubra* in hill pasture, Fionn chro.

This collection seems nearest to *Dasyscypha fugiens* (Bucknall) Massee, from which it differs in having even smaller asci and spores and in growing on Gramineae instead of *Juncus*.

MOLLISIA sp.

Apothecia scattered, cup-shaped, sessile, disc concave, pale grey, outer surface smooth, black with a light grey slightly incurved margin; excipulum of more or less globose cells, with thin, very dark brown walls, about 10 μ diameter, becoming clavate towards the margin and there replaced by about three rows of short, cylindrical, hyaline cells, about 10 × 3–4 μ, with protruding tips; asci clavate with slender stipe, about 90 × 12 μ, 8-spored, apex rounded with broad pore blue in Melzer's reagent, spores irregularly biseriate, elliptical, 1-septate, 15–17 × 4–5 μ; paraphyses slender, hyaline, slightly enlarged to 3 μ at the obtuse apex. On dried leaves, probably of *Nardus*, in hill pasture, Fionn chro.

This collection differs from *Niptera punctum* (Rehm) Sacc. in the long asci and in the iodine reaction, from *Mollisia melatephra* (Lasch) Karst. in the broader spores and in not growing on *Juncus*, and from *M. poae* (Fuck.) Sacc. in the broader spores.

Phialea incertella Rehm, Ann. Myc., iv, p. 485, 1906.

Apothecia erumpent, cup-shaped, with inrolled margin, about 300 μ wide and high, subsessile, externally greenish grey and smooth; excipulum of slender, subparallel hyphae, about 2 μ wide, inclined at a low angle to the surface, with completely gelatinised light brownish walls, base of the apothecium of somewhat similar parallel, vertical hyphae, with non-gelatinised walls. Similar slender brown hyphae form a narrow belt beneath the subhymenium, which latter is composed of slender, loosely woven, hyaline hyphae, about 1 μ wide. Asci cylindrical 35–40 × 5 μ, 8-spored, apex conical, with a small pore deep blue in Melzer's reagent, spores biseriate, cylindric-fusiform, 6–8 × 1·5–2 μ; paraphyses lanceolate, thin-walled, hyaline, about 4 μ wide, exceeding the asci by up to 25 μ. The apothecia arise singly from small subepidermal stromata in dead leaves of *Koeleria*, Harris, Isle of Rhum.

ACKNOWLEDGMENTS.

My thanks are due particularly to Professor Heslop Harrison for permitting me to join his party on Rhum; to Mr. McNaughton and Mr. Jamieson, factors on Rhum and Eigg respectively, for help in ways too numerous to particularise; to Miss G. Waterhouse for isolating and naming aquatic phycomycetes and moulds from water samples posted from the isles; to Mr. S. J. Hughes and Dr. M. B. Ellis for help in naming pyrenomycetes and moulds; to Mr. A. A. Pearson for checking drawings and specimens of agarics; to M. Henri Romagnesi for naming *Rhodophyllus radiatus* Lange; and to Dr. W. L. Gordon, Winnipeg, for naming the two species of *Fusarium*.

SOME SCOTTISH SMUT FUNGI.

By MALCOLM WILSON AND D. M. HENDERSON.
(Royal Botanic Garden, Edinburgh.)

(Read by title, 21st February 1952.)

USTILAGO HEUFLERI Fuckel

On *Erythronium oregonum* Applegate in the Royal Botanic Garden, Edinburgh. May 1951.

Sori on the leaves, producing blister-like swellings 2–5 mm. wide and up to 2 cm. long, frequently confluent, at first under the epidermis but later rupturing it. Spore mass powdery, black. Spores globose or sub-globose 16–19 μ in diameter, epispore 2 μ thick, somewhat punctate in appearance owing to the irregular thickening of the wall.

The plants in Edinburgh were received from Vancouver Island in 1936. According to Applegate (1935), the host, *E. oregonum*, is native to Western North America from Oregon to British Columbia. There seems to be no record of *U. heufleri* from this region. All records (Weiss, 1947) refer to Eastern North America where the fungis attacks the native species *E. albidum* and *E. americanum*. The fungus on *E. oregonum* in Edinburgh does not seem to attack *E. americanum* readily, if at all, for a clump of *E. americanum*, with a few infected plants of *E. oregonum* mixed with it, is quite free from infection.

There is no evidence to suggest whether the plants originally imported were infected or whether the infection came from some source in this country. *Ustilago heufleri* has not been recorded in Britain, but occurs on *Tulipa sylvestris* on the continent. According to Ciferri (1938), the species is closely allied to *U. ornithogali* which has been recorded in England on *Gagea lutea* (Ainsworth and Sampson, 1950).

TUBURCINIA * FILIPENDULAE (Tul.) Liro

On *Filipendula ulmaria* (L.) Maxim., Comrie, Perthshire, 1934. Collected by Dr. G. B. Wallace.

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* Owing to the present difference of opinion regarding the position of *Tuburcinia* and *Urocystis*, we have thought it better to follow Jorstad (1943) and Liro (1938) in the use of the name *Tuburcinia*.

Blairgowrie, Perthshire, June 1951. Collected by D. M. Henderson.

The only previous record of *T. filipendulae* in Britain is by Plowright (1889) who recorded it from Darnford Down in Surrey on *Filipendula hexapetala.* Ainsworth and Sampson quoted Plowright's description, but could not trace his specimens in British herbaria.

On the continent the fungus is fairly common in *F. hexapetala*, but only twice has a smut been recorded on *F. ulmaria*; once in Austria and once in northern Germany (Liro, 1938).

Liro regarded the species of *Tuburcinia* on *F. hexapetala* and on *F. ulmaria* as distinct, and called them *Tuburcinia filipendulae* and *T. ulmariae* respectively, but admitted that there was little to distinguish them. "The spores (of *T. ulmariae*) are on the average somewhat smaller, more irregular in shape and have a slightly lighter coloured membrane" (Liro, 1938). As comparison of the Scottish fungus with material of *T. filipendulae* on *F. hexapetala* (Vestergren, micromycetes rariores sel., collected in Gotland in 1898) reveals no appreciable difference between the two, it seems best to refer the fungus to *T. filipendulae.*

TUBURCINIA SOROSPOROIDES (Körn.) Liro

On *Thalictrum alpinum* L., Ben Laoigh, 1924. Collected by Dr. Malcolm Wilson.

The sori are produced in the laminae and petioles, and cause considerable distortion of the host tissue. Spore balls 27 μ in diameter. Fertile cells 8–9 μ diameter. Sterile cells 5 μ diameter. These dimensions are somewhat smaller than those given by Ainsworth and Sampson (1950) for this species on *Thalictrum minus*, but agree well with those cited by Liro.

There is no previous record of this fungus on *Thalictrum alpinum* in Britain, although it has been reported on this host from many localities on the continent (Liro, 1938, p. 474), and from Greenland (Clinton, 1906). In Britain it has been recorded on *Thalictrum minus* and on its variety *maritima* (Ainsworth and Sampson, 1950).

TUBURCINIA FISCHERI (Körn) Liro

On *Carex flacca* Schreb., John o' Groats, July 1947. Collected by Dr. E. Gray.

The rather insignificant sori are produced on brownish patches on the leaves and might easily be overlooked, so that the fungus may not be as rare in Britain as records suggest. It was collected in Forfarshire by William Gardiner at least a hundred years ago (Berkeley and Broome, 1850) and more recently in Dorset (Ainsworth and Sampson, 1950). In both cases the host was *Carex flacca*. On the continent several other species of *Carex* may serve as hosts.

TUBURCINIA FICARIAE (Unger) Liro

On *Ranunculus ficaria* L., Corstorphine, Edinburgh, May 1924, and on *Trollius europaeus* L., Lochranza, Arran, 1926.

These two collections were previously recorded under *Urocystis anemones* (Pers.) Schroet. (Wilson, 1927). Jorstad, however, follows Liro and assigns collections on these two host to *Tuburcinia ficariae*. According to Liro, the fertile cells of the spore balls of *T. ficariae* are almost completely surrounded by sterile cells, whereas in *T. anemones* and *T. ranunculi* the sterile cells form a very discontinuous sheath. The spore balls of the Scottish collections on *R. ficaria* and on *Trollius* are indistinguishable from one another but differ from collections of "*Tuburcinia anemones*" on *Anemone nemorosa* and on *Ranunculus repens* in the way described by Liro. Thus, in view of the fact that these two collections are readily distinguishable on morphological characters, it seems reasonable to assign them to Liro's species, *Tuburcinia ficariae*.

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Flora of Eigg: Additions and Notes.

By D. H. N. Spence.
(Department of Botany, University of Edinburgh.)

(Read by title, 17th April 1952.)

During July 1949 a party from Edinburgh University Biological Society stayed on the island of Eigg, which forms part of Watsonian vice-county 104. No plants new to the vice-county as a whole were discovered, but this short paper records those new to Eigg, and additional stations on this island of some other species, where these amplify previous reports. In all cases the recorded distributions of these species within v.c. 104 are cited. This has been done because v.c. 104 is composed of islands which vary greatly in size and distance apart. Therefore the recording of a species as new to, or in a new locality on, an island would seem of more value when related to the known distribution of the species within the vice-county than when cited baldly as a new station.

The nomenclature used is that of the Check List of British Vascular Plants, 1946.

Thalictrum alpinum L.

Round edge of lochan on the summit of Beinn Bhuidhe, under 1000 feet. New to Eigg.

V.c. 104. *Rhum*, Orval, Barkeval, Hallival, over 1000 feet (H. H., 1939) *; abundant down to 400 feet in limestone areas of Monadh Dubh (H. H., 1941). *Raasay*, sparingly on cliff ledges from Screapadal southwards, but plentiful as a kind of fringe to Loch na Meilich; *Scalpay*, much rarer (H. H., 1937). *Skye* (L., 1869) between Sligachan and Coir' a Mhadaidh (A., 1939).

Melandrium dioicum (L.) Coss. & Germ.

Abundant locally. Found in colonies of generally about twelve, but sometimes up to fifty, plants on cliff ledges of west and east

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* The initials which follow citations in the text refer to the papers listed below, being abbreviations for the authors as follows: R. M. Adam (A., 1939); G. C. Druce (D., 1911); J. W. Heslop Harrison (H. H., 1937, 1939, 1941, 1948, 1951); M. A. Lawson (L., 1869); W. R. and E. F. Linton (L. L., 1884); S. M. Macvicar (M., 1897); C. E. Salmon (S., 1916); Department of Botany, Durham University (D.U., 1938).

Beinn Bhuidhe, near Guala Mhor, and on the sea-cliffs north-west of Poll Duchaill; in association with *Luzula sylvatica* and *Filipendula ulmaria*, and generally ungrazed. Colonies also along stream-banks near Laig Farm and along Abhuinn cham Loinn.

V.c. 104. *Rhum*, sea-cliffs of Bloodstone Hill (H. H., 1939). *Eigg*, rare (M., 1897): rocks near waterfall, Laig Bay; *Muck*, on cliffs near Ard nan Van; *Soay*, a cliff north of Beinn Bhreac—in all these islands very rare and local, except in *Canna*, where it abounds in one of the woods, and *Pabbay*, on cliffs in the east (H. H., 1939). *Raasay*, quite rare; rocky woods on, or near, the cliffs at Screapadal and Hallaig, on the shingle near N. Fearns; flowers at Screapadal approach var. *zetlandicum* Compt. [see also H. H., 1951]; *Scalpay* (H. H., 1937). *Skye* (L., 1869).

SAGINA NODOSA (L.) Fenzl.

A few specimens near shore, and in marshy ground above Laig Bay; also at Poll nam Partain. New to Eigg.

V.c. 104. *Rhum* and *Sanday*, scattered, but not really common on bare heathy places (H. H., 1939). *Skye*, Loch Sligachan and Broadford (L., 1869).

OXALIS ACETOSELLA L.

Locally plentiful. In (often thick) bracken coverage, on north and east slopes of Beinn Bhuidhe (with *Anemone nemorosa*), at Poll nam Partain, and from Laig Farm to MacLeod's cave; extending to rock ledges and even fixed shingle of shore.

V.c. 104. Always rare and local, and often as a plant of rock ledges, but found on all the larger islands (*ex Flora of Rhum, Eigg, Canna, etc.*, H. H., 1939). All the islands except Fladday . . . to 1300 feet on Dun Caan (*ex Flora of Raasay, etc.*, H. H., 1937). *Skye* (L., 1869). See also H. H., (1941).

ULEX EUROPEAEUS L.

Rare; only on the south coast, away from human habitations. New to Eigg.

V.c. 104. *Rhum*, low down on the burn from Barkeval, and Kilmory road; *Canna, Sanday, Pabbay* (H. H., 1939). *Raasay*, near Raasay House and Fearns-Hallaig road; *Scalpay*, Allt Camas na Geadaig (H. H., 1937). *Skye*, Orbost, Broadford, Kyleakin (L., 1869). (H. H., 1948.)

MEDICAGO LUPULINA L.

Rare in the fields of Cleadale. New to Eigg.

V.c. 104. *Rhum*, on paths, etc., Kinloch and Kilmory (H. H., 1951). *Canna* and *Muck*, very rare near cultivated ground (H. H., 1939). *Raasay*, rare as a weed of cultivation near Churchtown Bay (H. H., 1937).

(V.c. 104. Druce, G. C., *Comital Flora of Britain*, Arbroath, 1932.)

VICIA SYLVATICA L.

One healthy colony on a wide ledge of the cliffs, in an area about 20 × 100 yards, on the east side of Beinn Bhuidhe, not far from Sron na' Iolaire. New to Eigg.

V.c. 104. *Rhum*, rare on the cliffs between Papadil and Ruinsval, and Camas na h-Acha; *Canna*, on west (H. H., 1939). *Skye*, Watersteen (L., MS., 1869), cliffs at Brittle (S., 1916).

PRUNUS AVIUM L.

In woods near the harbour, Poll nam Partain. New to Eigg.

V.c. 104. *Canna*, in woods (H. H., 1939). *Scalpay*, woods on south side; new to v.c. 104 (H. H., 1937).

COMARUM PALUSTRE L.

Abundant locally; common in marshy ground to west and north-east of Houlin in Cleadale, and less commonly on the moor between the Post Office and the Sgurr.

V.c. 104. *Eigg*, rare in a ditch near the school-house (M., 1897). On all the bigger islands except Eigg, and occasionally very plentiful, as on the alluvial flats at Kilmory, *Rhum* (*ex Flora of Rhum, Eigg, Canna, etc.*, H. H., 1939). *Raasay*, very local indeed, Loch a' Chadhacharnaich; *Rona*, Loch Braig; *Scalpay*, south side, on marshy ground (H. H., 1937). *Skye* (L., 1869).

SAXIFRAGA OPPOSITIFOLIA L.

Frequent, at about 450 feet, on the east and west cliffs of Beinn Bhuidhe. New to Eigg.

V.c. 104. *Rhum*, common on all the mountains, descending almost to 100 feet just south of Bloodstone Hill . . . and also in Dibidil (H. H., 1939). *Skye*, Quirang and Storr (L., 1869).

SAXIFRAGA AIZOIDES L.

Locally abundant in damp areas on or near cliffs. Observed on north and east cliffs of Beinn Bhuidhe, as well as those above the Singing Sands (see below), and in the cliff gullies at the south of the island.

V.c. 104. *Rhum*, at sea-level in ravines to the north of Kilmory Bay, and on limestone in the same area; *Eigg*, cliffs above Singing Sands (H. H., 1939). *Raasay*, on the cliffs and slopes from N. Fearns to Screapadal, chiefly where water trickles down; rare near Loch na Mna; one station is at sea-level (H. H., 1937). *Skye*, Quirang and Storr (L., 1869).

PARNASSIA PALUSTRIS L.

Locally abundant. In damp-flush ground below, or ledges on, north and east cliffs of Beinn Bhuidhe, and cliffs, often seaward, at south and west of island; also in marshes at Cleadale.

V.c. 104. *Rhum*, *Eigg*, *Canna*, *Sanday*, *Muck*; not common, and chiefly in sandy areas near the sea (H. H., 1939). *Raasay*, only on the shores of Loch a' Chadhacharnaich; very rare in view of its abundance on Skye (H. H., 1937). *Skye*, between Storr and Steinscholl (L., MS., 1869); between Loch an Eilean and Loch Harport shore (A., 1939).

MIMULUS GUTTATUS DC.

By streams in Cleadale. New to Eigg.

V.c. 104. *Soay*, in small amount (H. H., 1939). *Skye*, naturalised in woods and ditches about Dunvegan: also in many open marshy places between Sligachan and Broadford (L., 1869); beside Loch an Eilean and Loch Harport (A., 1939). (Listed by J. W. Heslop Harrison in "Introduced Vascular Plants in the Scottish Western Isles," in *The North-Western Naturalist*, 1948).

UTRICULARIA MINOR L.

Pond at Laig. New to Eigg.

V.c. 104. *Rhum*, *Muck*, *Soay* (H. H., 1939). *Raasay*, *Rona*, *Scalpay* (H. H., 1937). *Skye*, Steinscholl, Sligachan (L., 1869).

MENTHA ARVENSIS L.

Small colony by ditch near the Post Office. New to Eigg.

V.c. 104. *Rhum*, field at Kilmory (H. H., 1951). *Raasay*, *Scalpay*, fields (H. H., 1937). [Entry bracketed and queried, M., 1869].

(V.c. 104. Druce, G. C., *Comital Flora of Britain*, Arbroath, 1932.)

LISTERA OVATA Br.

Besides being seen in one previously recorded habitat, Cleadale, a new colony of about twenty plants was found on the east side of Beinn Bhuidhe, on a wide cliff ledge in association with *Melandrium dioicum*, *Luzula sylvatica*, *Filipendula ulmaria* and *Vicia sylvatica*.

V.c. 104. *Eigg*, one plant, north side of Sgurr (M., 1897); rare near Cleadale (H. H., 1939). *Raasay*, not uncommon on limestone near Screapadal and Rudha na Leac, just above the old path in each case (H. H., 1937). *Skye*, a few plants high up on a grassy cliff, Uig (L. L., 1884).

LUZULA PILOSA Willd.

In small quantity on ledge near gully of Allt na Cuagaich; also on east cliffs of Beinn Bhuidhe on wide ledge near Sron na' Iolaire.

V.c. 104. *Rhum*, along south side of Loch Scresort; *Eigg*, near Laig waterfall (H. H., 1951). *Muck*, sparingly (H. H., 1939). Sparingly, but widely distributed; a new county record, for v.c. 104 was the only vice-county from which it had not been previously recorded (*Flora of Raasay, etc.*, H. H., 1937).

SPARGANIUM ANGUSTIFOLIUM Michx.

Lochans to the west of the Sgurr. New to Eigg.

V.c. 104. *Rhum* and *Soay*, frequent in lochs and pools (H. H., 1939). *Raasay* and *Scalpay*, somewhat local in lochs (H. H., 1937). *Skye*, as *S. natans* (L., 1869); *S. affine* Schneiz. (= ? Schnizl.), peaty pool between Uig and the Quirang (L. L., 1884).

GYMNOCARPIUM DRYOPTERIS (L.) Newm.

One patch in a gully near Loch Beinn Tighe. New to Eigg.

V.c. 104. *Rhum*, very rare, only recorded from scree on western slopes of Orval (H. H., 1939). *Raasay*, *Scalpay* and *Longay*, shaded wooded and rocky places, rather local (H. H., 1937). *Raasay*, less frequent than formerly supposed (D.U., 1938). *Skye*, Orbosh, Kyleakin (L., 1869).

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